Eugene B. Power
Universal Microfilms
313 N. First St.
Ann Arbor, Mich. -1

Industrial QUALITY CONTROL

Vol. XV, No. 1
July, 1958

In This Issue

Quality Control—What is it?

The Median, Quasi-Range Method of Acceptance Sampling

Normal or Log-Normal Probability Paper for Plotting Experimental Data

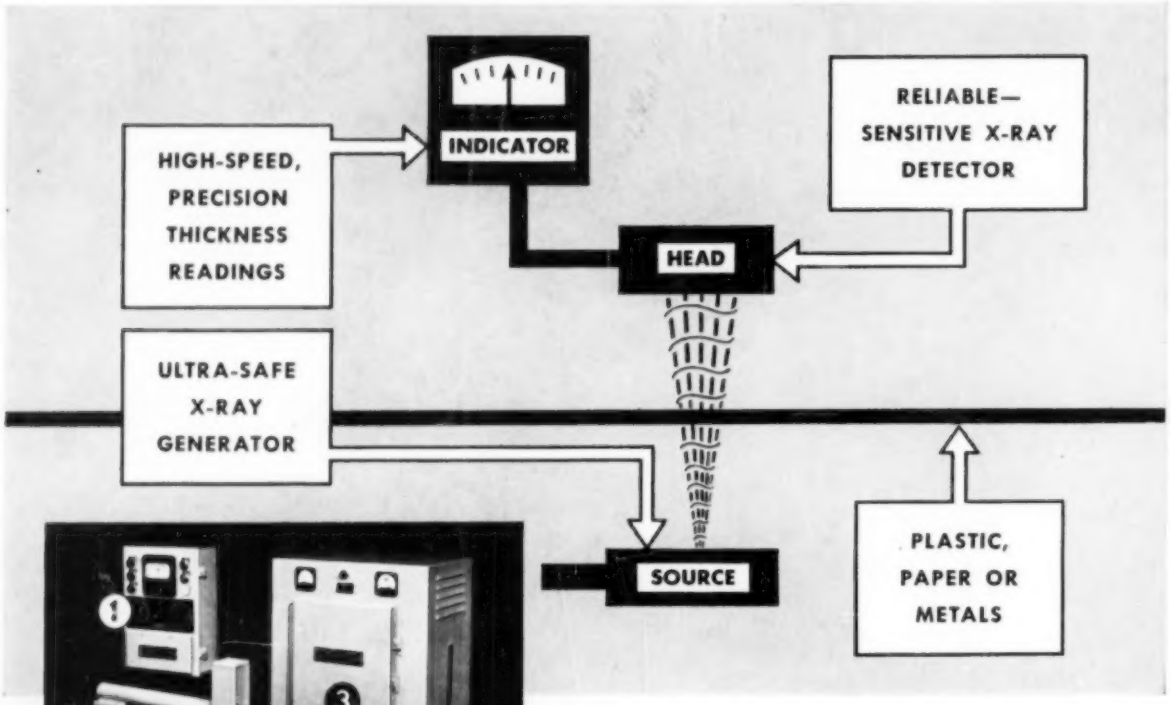
Experimental Determination of Optimum Operating Conditions, Part I—Fitting of Response Surfaces Using Fundamental Mathematics and Statistics

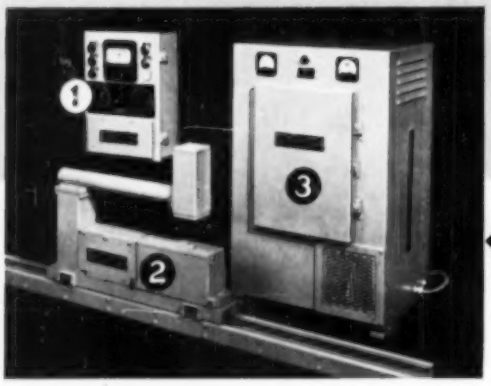
QUALITY through Scientific Methods

Journal of the
AMERICAN SOCIETY FOR QUALITY CONTROL

FOILS and FILMS Moving at High Speed GAGED TO MILLIONTHS by *New*

Sheffield Measuray Model 25PT





1. CONTROL STATION WITH DEVIATION INDICATOR
2. X-RAY SCANNING UNIT WITH EMITTER AND DETECTOR
3. MAIN POWER CABINET

PRINCIPAL FEATURES

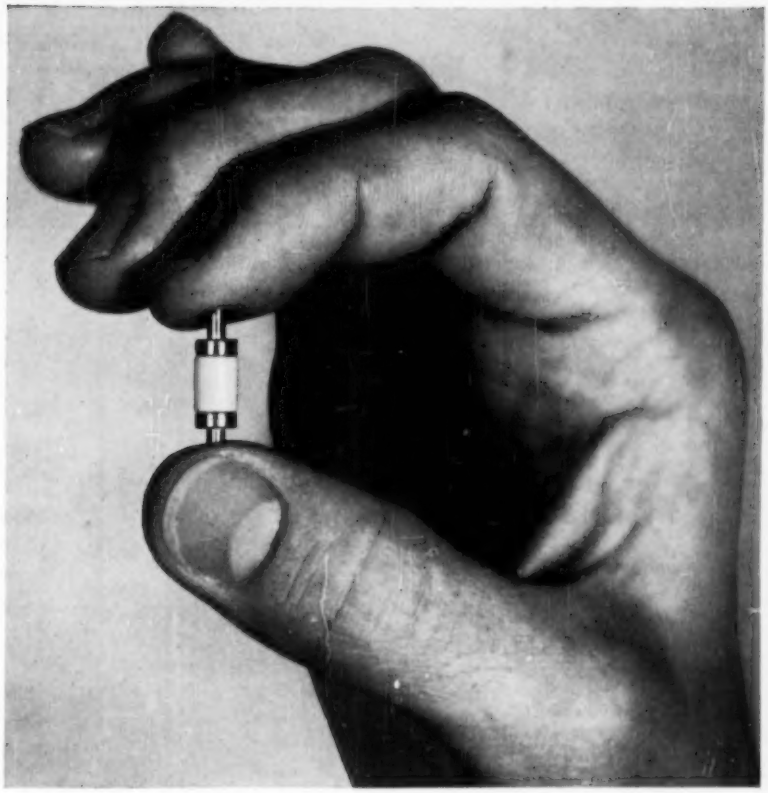
- Non-contact thickness or density measurement
- Accuracy obtained by 100% controlled electronic source and detector
- Scintillation type detector for reliable and sensitive X-Ray detection
- Short pulsing assures ultra-safe X-Ray generation
- High-speed response obtained by all-electronic measuring circuits
- Measures thick or thin plastics, paper and metals in sheet or strip form
- Suitable for "building block" expansion to record, sort and control — manually or automatically
- Low cost installation and maintenance

For Engineering Data Sheet No. 113-57, write to the Sheffield Corporation, Dayton 1, Ohio, U.S.A., Dept. 5.

the SHEFFIELD corporation
of Bendix Aviation
manufacture and measurement for mankind

8037

NEW DIODE SPEEDS VOICES— AT 6,000,000,000 C. P. S.



How the radio art can be improved through solid state science is illustrated by a recent development at Bell Telephone Laboratories. To make voice signals travel by microwaves they must first be "converted"—caused to vibrate at billions of cycles per second. To date, it has been possible to accomplish this conversion only at the cost of appreciable loss of signal energy. Could a more efficient converter be provided?

In the field of solid state science it was known—as a laboratory curiosity—that semiconductor diodes can be made not only to convert the frequency of signals, but also to amplify them. At Bell Laboratories Dr. Arthur Uhlir, Jr., and his associates calculated that this amplifying action could be put to practical use. They proved the point by developing a junction diode converter which can deliver up to 40 times as much signal energy as previous converters.

This efficient new converter will be applied in a new Bell System microwave highway able to transmit thousands of telephone conversations and a dozen television programs simultaneously at six billion cycles per second. In other forms it is being developed, under Signal Corps contract, for radar and military communications where more efficient frequency conversion can also be used to advantage.

This development is an example of the many different ways in which Bell Laboratories works to improve your telephone service and communications at large.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

EDITORIAL BOARD

MASON E. WESCOTT, *Chairman*
University College, Rutgers University, New Brunswick, N. J.

CHARLES A. BICKING
The Carborundum Co.

ALBERT H. BOWKER
Stanford University

A. C. COHEN, JR.
University of Georgia

ALLEN T. CRAIG
State University of Iowa

CECIL C. CRAIG
University of Michigan

HAROLD F. DODGE (Retired)
Bell Telephone Laboratories, Inc.

A. V. FEIGENBAUM
General Electric Co.

ENOCH B. FERRELL
Bell Telephone Laboratories, Inc.

DAME S. HAMBY
North Carolina State College

CHARLES R. HICKS
Purdue University

HOWARD L. JONES
Illinois Bell Telephone Co.

B. H. LLOYD
Price Waterhouse & Co.

CARL E. NOBLE
Kimberly Clark Corp.

MARY N. TORREY
Bell Telephone Laboratories, Inc.

EDWARD M. SCHROCK
American Radiator and Standard Sanitary Corp.

1958-59 SOCIETY OFFICERS

President
C. E. FISHER
Bell Telephone Laboratories, Inc.
New York, N. Y.

Vice Presidents
CLARENCE R. BURDICK
Houdaille Industries, Inc.
Detroit, Mich.

A. V. FEIGENBAUM
General Electric Co.
New York, N. Y.

J. Y. MCCLURE
Convair Div. of
General Dynamics Corp.
Ft. Worth, Texas

ELLIS R. OTT
Rutgers University
New Brunswick, N. J.

Executive Secretary
L. S. EICHELBERGER
A. O. Smith Corp.
Milwaukee, Wis.

Treasurer
ALLAN M. HULL
United Air Lines
San Francisco, Calif.

Junior Past President
LEON BASS
General Electric Co.
Cincinnati, Ohio

1958-59 EXECUTIVE DIRECTORS

D. G. BROWNE
The Broderick Co.
Muncie, Ind.

ROCCO L. FIASCHETTI
Ansco, Division of General Aniline & Film Corp.
Binghamton, N. Y.

GERALD J. LIEBERMAN
Stanford University
Stanford, Calif.

AUGUST B. MUNDEL
Sonotone Corp.
Elmsford, N. Y.

WARREN R. PURCELL
Raytheon Mfg. Co.
Lowell, Mass.

ADVISORY COUNCIL

E. U. CONDON, *Chairman*
Department of Physics
Washington University
St. Louis, Missouri

M. HERBERT EISENHART, *Chairman*
Bausch & Lomb Optical Co.
Rochester, New York

HERMON F. SAFFORD, *President*
Ohio Rubber Co.
Willoughby, Ohio

WALTER A. SHEWHART, *Retired*
Bell Telephone Laboratories, Inc.
Murray Hill, New Jersey

DIVISIONS OF ASQC

Administrative Applications Division
CARL E. NOBLE
Kimberly Clark Corp.
Neenah, Wis.

Aircraft & Missiles Division
PAUL E. ALLEN
Beech Aircraft Corp.
Wichita, Kans.

Automotive Division
DONALD M. SPATH
General Products Corp.
Jackson, Mich.

Chemical Division
PAUL K. LEATHERMAN
Malinckrodt Chemical Works
St. Louis, Mo.

Electronics Division
HENRY A. SCHUMER
International Resistance Co.
Skyland, N. C.

Textile Division
KENNETH K. EDGAR
Henderson, Lindsy, Michaels
Greenville, S. C.

INDUSTRIAL

Quality Control

Vol. XV, No. 1 July, 1958

EDITOR:
Mason E. Wescott
University College
Rutgers University
New Brunswick, N. J.

BUSINESS MANAGER
William P. Youngclaus, Jr.

MANAGING EDITOR:
George R. Foster

PRODUCTION:
Alan T. Zingelman

DEPARTMENT EDITORS:
W. D. Baten, Book Reviews
P. C. Clifford, T. A. Budne, Problems
E. R. Ott, Practical Aids
R. A. Wylie, What's New
J. M. Juran, Management's Corner
M. E. Wescott, Scrap Box
Paul A. Robert, Supervisor's Circle
A. T. Zingelman, Section Briefs
L. S. Eichelberger, ASQC News

Contents

ARTICLES

What is Quality Control?
C. C. Craig 5

Acceptance Sampling of Lots by the Median, Quasi-Range Method 8

The Median, Quasi-Range is a simplified method of variables acceptance sampling developed for military use for electron tubes to replace the mean, average-range method.

Plotting Experimental Data on Normal or Log-Normal Probability Paper
Enoch B. Ferrell 12

This article discusses the use of normal and log-normal probability graph paper plotting experimental data having normal and skewed distributions. Yankees and Giants batting averages are used as an example of normal distribution; transistor currents for skewed distribution. A new concept of limits is introduced to describe the dispersion on skewed distributions.

Determination of Optimum Operating Conditions by Experimental Methods, Part I—Mathematics and Statistics Fundamental to the Fitting of Response Surfaces
Ralph Allan Bradley 16

As the forerunner to a subsequent article on response surface fitting by Dr. J. S. Hunter, this article briefly discusses the mathematical concepts needed to understand the techniques. Included are multiple regression, factorial designs, theory of maxima and minima, and direction of steepest ascent or descent in multi-dimensional space.

DEPARTMENTS

From the President's Desk, *The Outlook for the New Year* 4
Book Reviews 20
Report of the Twelfth Annual Convention 21
Society Officers, Executive Directors 22
Board of Directors 23
Supervisor's Circle, *Quality Control Do-It-Yourself Kit*, E. R. Conolly . . . 28
From the Scrap Box, *Practical Application of Management by Exception*, Julian H. Toulouse 30
Section Briefs 32
Section Calendar 33
What's New? 38
Clinics, Conferences, and Courses 39-40
Product Education Service 39
Positions Available 40
Positions Wanted 40
Consulting Services 40

Industrial Quality Control is published monthly by the American Society for Quality Control, Inc. Entered as second-class matter on Sept. 18, 1950 at the post office at Milwaukee, Wis.

Industrial Quality Control is sent to all members of the Society as one of the privileges of membership; yearly subscription is $3.00 of the membership dues. Subscriptions from non-members are not accepted. Subscriptions for company, public, and university libraries are: 1 yr.—$9.00; 2 yrs.—$17.00; 3 yrs.—$25.00; 5 yrs.—$40.00. Back issues of Vols. I-X are available at $6.00 per volume including index; Vol. XI, $9.00; XII-XIII-XIV, $10.00 ea. Individual copies are $1.00 each. Microfilm editions by volume are also available. The cost per volume is I-VII, $10.00; VIII, $1.50; IX, X, $1.60 ea.; XI, $1.70; XII, $1.85; XIII, $2.00.

Orders for library subscriptions, back issues, and microfilm editions should be accompanied by remittance made payable to the American Society for Quality Control, Inc. *Orders under $3.00 must be accompanied by remittance.*

Industrial Quality Control is regularly indexed in the *APPLIED SCIENCE & TECHNOLOGY INDEX* published by The H. W. Wilson Company, 930 University Avenue, New York 52, N. Y.

Neither this magazine nor any portion of it may be copied or otherwise reproduced without written permission of the copyright owner. Requests for copyright release should be addressed to the editor, Mason E. Wescott. The statements and opinions given in the articles and papers in *Industrial Quality Control* are the views of the authors and are not necessarily those of the Society.

Notification of address change should be sent both to the secretary of your section and to the Executive Secretary's office. Allow approximately seven weeks for the change to become effective.

Executive Secretary and Publications office: Rm. 6197 Plankinton Bldg., 161 West Wisconsin Avenue, Milwaukee 3, Wisconsin. Society's New York Address: Rm. 965, 463 West St., New York 14, N. Y. West Coast advertising representative: J. E. Munford Co., The Mission Building, Suite "C", 1425 Mission Street, South Passadena, Calif.; and 420 Market Street, San Francisco 11, Calif.

Address all correspondence to American Society for Quality Control, Inc., Rm. 6197 Plankinton Bldg., 161 West Wisconsin Ave., Milwaukee 3, Wisconsin.

Copyright 1958
American Society for Quality Control, Inc.
Printed in U.S.A. All rights reserved

From the President's Desk

The Outlook for the New Year

The beginning of a new year is traditionally the time to review recent progress and to chart a course for the future. This is a pleasant task for me, because I am able to report very substantial gains during the past year and to point to factors that clearly indicate continued growth for ASQC in the coming months.

During 1957-58 the Society maintained its steady growth pattern, as measured in terms of number of members, number of sections, and strength and influence of its activities. There is every reason to believe that this growth will continue; enthusiastic section officers and committees, guiding the activities locally, will be supported even more vigorously this year by strong committee work at the national level, with particular emphasis in the areas relating to program and speakers, education and training, relations with other professional societies, and professional development. The widespread participation and the outstanding results in the Saddoris Award Competition for Section Management indicate genuine interest in performing well the many operations that are essential to Society strength and stature. This program will be continued, with as much help as possible being provided in the areas involved.

Three important strides were taken by the Society last year to enhance its professional stature and that of its members:

1. Adoption of an amendment to the Constitution establishing professional requirements for the Member grade, thus completing a schedule of such requirements for corporate members of all grades.

2. Vigorous prosecution of the program developed by the Committee on Professional Development, as outlined to you on this page last month.

3. Formation of the General Technical Council with the view to planning and integrating more effectively the work of the divisions, technical committees and professional committees of the Society.

These programs will move forward, actively, during the coming year, with every expectation that further progress will be evident.

Last year saw the Society solve a serious financial problem, thanks to the sections and divisions that responded to the appeal for financial assistance following failure of the dues increase amendment to pass. This splendid support enabled the Society to move forward without interruption in its overall program. Later, the change in the nation's economic condition was reflected in our advertising income, which dropped appreciably during the fourth quarter, but in total, the Society adhered closely to budget for income and for expenses. The support of the membership in approving the dues increase amendment this year is greatly appreciated by the Officers and Directors. Without resorting to special appeals for financial aid, the Society can proceed with the many activities designed to be of real benefit to the members. An operating budget essentially the same as last year's is planned for 1958-59.

Summer months normally mark a lull in Society activities, particularly in the area of meetings. Fortunately, much of the planning for the year has already taken place. Many section meetings and programs have been arranged, conferences have been scheduled and their programs established well in advance, and educational activities have been planned by many groups within the Society. The very successful 12th Annual Convention held in Boston last May offered a fine opportunity for many of the Society's Committees and Councils to meet, to review the past year's work and to plan for the coming year. Results indicate that programs in all areas of activity are well advanced, with a great deal of thought being given to the individual objectives and to means of achieving established goals. A banner year is in the making.

The real success of the year, however, will be measured in terms of the benefits derived by each member of the Society. These will be substantial for all members, but will be greatest for those who contribute in like manner. I earnestly solicit your active support and participation in the affairs of the Society.

C. E. Fisher

The 1957 Shewhart Medalist
C. C. Craig

What is Quality Control?

C. C. CRAIG

University of Michigan, Ann Arbor, Mich.

I have had some weeks now in which to try to grow accustomed to the idea that I was to receive the Shewhart Medal, but now that it has taken place, I find that I was not prepared for it at all. I am almost overwhelmed and my heart is full. I hope you sense how I feel for I cannot find the words to tell you.

I am fortunate in having been pretty well informed of the affairs and the progress of the American Society for Quality Control from its beginnings, in knowing the qualities and the devotion of the officers of our Society and of many others who have made important contributions. I know the great merits and accomplishments of the former Shewhart medalists, all of whom I count among my personal friends. All of this makes me know how great this honor is and leaves me profoundly and humbly grateful. I will admit that while I listened to one of the best friends a man could ever have, Ed Olds, throw restraint to the winds, I came the closest I have been able to believing I might deserve this high distinction.

I know it is technically improper for me to thank the members of the Shewhart Medal Committee, for it was their duty to make an objective choice, but I cannot help feeling very grateful to them. But I can and I do thank from the bottom of my heart the loyal friends who put my case so strongly. In particular I must single out my own Michigan section. It has been a very great privilege to have been associated with this group for 15 years. From my intimate knowledge of its members over this period I claim, gentlemen, that they deserve your most serious consideration as the finest section of the American Society for Quality Control.

The American Society for Quality Control is a truly remarkable organization. I could very easily use all of my time elaborating on the wonderful progress our Society has made in its first 12 years. But we are still very young and we still face many problems. I believe I can best serve you by briefly and frankly discussing with you some questions concerning quality control and the American Society for Quality Control that have been more or less insistently on my mind ever since the quality control movement and our Society began their extraordinarily vigorous growth. I don't mean to lay down answers; I rather hope you will agree that the issues I raise are important and that some of you will see some of them the way I do. Of course I am going to discuss them from my own point of view which is that of a professor of mathematical statistics. I doubt if I could really succeed in talking from any other point of view, but I make bold to believe that this point of view should be presented in considering the issues I have in mind.

First I am going to confess to what may seem a surprising degree of ignorance and ask, "What is quality control?" I remember that in one of my early attempts to teach an evening course in quality control to some industrial personnel in Detroit, word came back to me from a member in the class that I didn't know the first thing about quality control! In the sense that he meant quality control, he was more than half correct. In the 14 years since I think I have repaired my ignorance to some extent, but I am still in some confusion about just what the term "quality control" in the name of our Society does in fact mean. Let me say that I am aware, as I really was in 1944, that quality control in practice includes much more than the application of statistical methods. I'll grant that this non-statistical side of quality control is very important but much of it lies outside of my particular interest and competence. With respect to it I will make only the passing remark that all of it existed before 1943 and that some of it still belongs to the world

1957 Shewhart Medal Citation

The 1957 Shewhart Medal is awarded to Dr. Cecil C. Craig in recognition of his many contributions to statistical quality control through his leadership as an original investigator; as a teacher of mathematical statistics to university students; as a pioneer in the presentation of sound statistical principles to men in industry; as an advisor to individual sections; as a member of the Editorial Board and of various important committees including the Examining Committee, the Applied Methodology Committee, and the Committee on Education and Training; and as an active participant in National Conventions and Regional Conferences of the American Society for Quality Control.

where opinions are likely to masquerade as facts.

I am much more interested in the science of quality control. Now the science of quality control is not all statistics either but I presume that the essential attitude here is that of trying to get at facts, facts that will stand the test of experimental verification. But as soon as one is dealing with facts, a basically important fact is that quality characteristics are random variables and the laws of chance are the ones they obey. I don't think I have to belabor the historical circumstance, that no matter what all quality control may consist of, it was the application of statistical methods that got it off the ground, largely gives it the characteristics of a science, and which cannot be neglected if quality control is to become a profession.

My next question is a related one: "Just how seriously is a competent quality control man going to have to study statistical methodology?" Could it really be that he might even have to understand a little mathematics and probability theory? I know a lot of you are thinking, "Ah, now comes the hard sell!" but I am going to fool you, at least in part. I am going to assume that you, at least most of you, will agree, as a sort of abstract proposition, that a man in a responsible position in quality control should have available to him a battery of statistical tools he can use in a sound manner. If you don't, the award you have just given me shouldn't have been named after Shewhart and neither I nor most of my predecessors should have had it. But in spite of this our present situation can almost be compared to that of a large and apparently flourishing church in which presumably the members subscribed to its creed when they joined, but also in which one finds a great part of the membership wouldn't want anybody to think that they are really Christians. If this analogy seems a bit farfetched to you, let me try another. Suppose an innocent, uninformed visitor from Mars should happen to find himself on the campus of one of our large universities, say my own. The size of the physical plant and the crowds of young people would arouse his curiosity, I presume. He would soon find out that he was looking at what is on the whole an educational institution, that most students find it rather expensive to attend, that there are entrance and graduation requirements. Would this information prepare him for the attitude he would find in a good half of almost any freshman or sophomore class he might visit? Would he be shocked at the firm resolution that no professor is going to make eggheads out of them?

Now perhaps I have shared some of the innocence of the man from Mars with respect to the American Society for Quality Control, even if I have long since been disillusioned with college students. Might one be forgiven for having supposed that if a kit of statistical tools with some basic understanding of how they work are essential for scientific quality control there would be a high proportion of American Society for Quality Control members eager to learn? I know I do an injustice to a lot of people who really did sweat over some books, but how typical are such persons? American Society for Quality Control sections do run a lot of training courses—how many are run at better than a high school level? Isn't it just about standard practice for American Society for Quality Control speakers to begin by reassuring their audiences that they are not statisticians and do not really know anything about statistics? I am reminded of the fellow who would be interested in attending an evening course in quality control provided that the instructor would avoid probability. Maybe statistical methods are an essential to do a good quality control job but judging from actions, not words, the weight of opinion seems to be that we must keep that "longhair" subject in its place.

I now turn to my third question: "What must the American Society for Quality Control do to achieve professional status?" I know that our present national officers, as well as many of our more responsible members, are genuinely concerned with this problem. We do have an excellent report in the February issue of *Industrial Quality Control* by Val Feigenbaum on this subject which we all should have read carefully at least twice. But as good as this is, I hope you clearly caught the implication that it is only preliminary—it states some problems and defines some goals. These problems are difficult and the goals are not going to be reached without real effort.

Feigenbaum's report does a very necessary job of describing the things a professional quality control man should be able to do and the services he can render to his company. This is good but what I am more concerned with at the present moment is the training program that should be laid down for a young man who wishes to qualify for our new profession. In the report it is anticipated that this training will eventually be offered in universities. I, too, anticipate that this will happen. If it does, then a curriculum will have to be laid out, consisting, I suppose, of some existing courses and of others that may have to be created for it. If I were to undertake to set up such a curriculum I would certainly need advice from Val Feigenbaum and our national officers though I think I have a pretty good idea of an important part of it. But you know that a list of courses with well chosen names would not necessarily lead to a really professional degree. In a good professional school standards also have to be considered. Let me only say that principles must be taught as well as facts, that the whys have to be insisted upon as well as the hows. After all, what is it that differentiates a profession from a trade?

I believe the main point I want to make must be emerging fairly plainly. The gap between the present American Society for Quality Control and an equally numerous professional society is not one that can be closed in any casual fashion.

But related to this is another matter I cannot refrain from mentioning. I assume that in the process of becoming a profession, quality control should become fairly well defined. I was pleased with the Feigenbaum report in this respect. It did not seem to me to imply that a professionally qualified quality control man should also be professionally qualified in operations research, linear programming, business forecasting, market research and what have you? We do have some men in our organization, who have training they did not acquire in quality control, who are equipped to do professional jobs in one or more of these areas. I am not referring to them when I say I do not like to see amateurs competing with professionals. Let us at least first become professionals in quality control as defined in the Feigenbaum report.

The final question has an even more personal angle to it than the others: "What is the role of a professor in the American Society for Quality Control?" Well, profes-

sors have always been visible in the American Society for Quality Control and not without honor. Without checking positions in the directory I recognized 35 of our Fellows as professors. When it comes to handing out Shewhart Medals the record is striking. Five of the ten recipients, so far, including the last four, have been professors, and another had only recently resigned his academic post. I wonder how many of you are thinking to yourselves, "That sort of thing has gone far enough!"

Historically during the series of meetings and maneuvers that led to the founding of the American Society for Quality Control there were some academically oriented views presented concerning the direction the new society should take. They didn't meet with much success. The new American Society for Quality Control was saved from academic taint from which it has managed to keep itself pretty free although the editor of *Industrial Quality Control* has always been a professor and another is now a vice-president. Actually by not pushing too hard in unpopular directions, I believe the professors have exerted more than a negligible influence on the American Society for Quality Control.

I can't resist two remarks about our group of professors. First they are not nearly as homogeneous as I suspect most of you believe. Not all of them are professors of statistics and not all of the professors of statistics are professors of mathematical statistics. Second, we simply do not have among those who are active in the American Society for Quality Control any of the real simon pure, away up in an ivory tower, type. The lack of sympathy would be mutual. But I will say this of professors in general: Contrary to popular folklore, common sense and good judgment are found among them as often as anywhere else.

Now why are so many professors in the American Society for Quality Control? First, there is the sordid fact that a good many do make contacts that lead to consulting fees to augment incomes that need augmenting. But very few of us offer serious competition to professional consultants. The first obligation of nearly all of us is to full time university jobs. The more important reason for our presence is more complicated but it is something like this. We not only teach statistics but we believe thoroughly in statistics. We are devoted to selling statistics, that is, statistical methods, to whomever will listen. To the extent that the quality control movement rests on a statistical foundation, this movement presents a real challenge to us. The opportunity exists to very significantly increase the importance of our subject, a thing every academic man yearns for. There is also, we hope, a need created for an educational job of the kind for which universities were created. If we take part in it, we also hope that our initiative and effort will receive proper recognition.

There are these and other benefits the professor stands to get from the American Society for Quality Control. The things he has to give the American Society for Quality Control are more important to you. These are about as obvious as the things he gets. He does have special knowledge and special skills. In most cases he has amply demonstrated his willingness to share these. Of course some of the best teachers won't even try to be entertainers and some haven't learned how much sugar coating must be put on the pill before it will be swallowed at all. I do believe that with very few exceptions the professors have contributed as much to the educational program of the American Society for Quality Control as they have been allowed to.

I want to return once more to the matter of professional status and professional standards for the American Society for Quality Control. This is the subject the professors have been concerned with from the beginning. Is any real progress being made or not? I personally feel more encouraged now than I have before.

Let me tell you two final things about your professors. First we are all agreed that it is not nearly as important to try to teach beginners a whole cookbook full of statistical recipes as it is to try to instill in them the attitude of looking for the facts and then the habit of thinking about them statistically. Success there opens the way to real progress. Second, how does one make a professor really happy? By giving him a group of students who really want to learn what he has to teach them.

Chemical Division News

Fifty-one persons attended the annual meeting of the Chemical Division in Parlor A of the Hotel Statler in Boston, Massachusetts at 6:30 pm, May 26, 1958.

The Chairman, M. S. Renner, outlined the accomplishments of the past year:

Cosponsorship with the Metropolitan Section and Stevens Institute of the Second Stevens Symposium, and presentation of copies of the Symposium Transactions to all members;

Holding of the First Technical Conference in Philadelphia;

Cosponsorship with the local sections of three successful courses in Response Surface Methodology;

The sponsorship at Harvard Business School of the Statistical Methods for Process Development short course;

Continued membership growth to 848 members, representing an increase of 19.3 percent;

Plans virtually completed for the Second Technical Conference at Buffalo, New York, October 2-3, 1958;

A treasury with assets of around $11,000;

Active pursuit of plans to back the publication of a new journal of statistics jointly sponsored by ASQC and ASA for the worker in the physical, chemical, and engineering sciences.

The tellers committee reported 431 ballots were returned. The following were elected:

Chairman	P. K. Leatherman	Secretary	Otto A. Kral
Chairman-Elect	V. B. Shelburne	Treasurer	Ben H. Carpenter

Councillors

Dist. 1	M. E. Blew	Dist. 9	John Waldner
Dist. 2	N. C. Hodge	Dist. 10	Paul R. Haas, Jr.
Dist. 3	Harold Davidson	Dist. 11	Karl J. Bauer
Dist. 4	R. Vance Ward	Dist. 12	Harland J. Johnson
Dist. 5	H. Mack Truax	Dist. 13	R. C. Manring
Dist. 6	M. H. Replogle	Dist. 14	J. H. Moyer
Dist. 7	K. E. Frye	Dist. 15	Walter S. Adams
Dist. 8	Robert Remke	Dist. 16	J. I. Black

Acceptance Sampling of Lots

by the median, quasi-range method

EDITORIAL NOTE

Since 1952, Military Specifications on Reliable Electron Tubes have incorporated a variables sampling requirement for lot acceptance on tube characteristics which are adequately described by a normal distribution.

In December, 1954, Messrs. B. Goldsmith of the Raytheon Mfg. Co., and A. Davies of the General Electric Company proposed that a subcommittee of the Joint Electron Tube Engineering Council Committee on Sampling Procedures (JETEC-11) be assigned to develop a method alternate to the variables plan specified on the Reliable Electron Tube Specifications. The plan specified used the sample mean as a measure of lot centering, and the sample average-range as a measure of dispersion. A subcommittee of JETEC-11 consisting of Messrs. S. Babcock of the Radio Corporation of America (Chairman), A. Beck of Tung Sol Electric, Inc., A. Davies of the General Electric Company, B. Goldsmith of the Raytheon Mfg. Company, and E. Torkelson of the Bell Telephone Laboratories was assigned the task.

A suitable alternate variables sampling plan using the Median as a measure of lot centering and the Quasi-Range as a measure of lot dispersion was developed. This plan was submitted to the Government Agencies in April, 1955. The plan was accepted and has subsequently appeared on many Reliable Electron Tube Specifications, and is now part of the Inspection Instructions for Electron Tubes dated 5 October 1955.

In order to further publicize this Median, Quasi-Range Plan and the work of JETEC-11, the subcommittee was assigned the task of preparing a paper describing the Plan. Early in this work it was decided to divorce the Plan from the Variables Plan on Military Electron Tube Specifications, as there is much terminology used therein which is not commonly known outside of the electron tube industry.

Key contributions were made by Miss M. Torrey and Mr. M. Sobel of the Bell Telephone Laboratories on the distribution of quasi-ranges.

In October, 1956, the paper prepared by this Sub-Committee was accepted by JETEC-11, and submitted to the JETEC Council. The JETEC Council approved it in May 1957, and advised that it may be submitted to technical journals for publication.

It was submitted to *Industrial Quality Control* and, after some further revisions, approved and released on March 17, 1958 for publication as herewith presented.

Introduction

The purpose of this paper is to introduce the Median, Quasi-Range Method for controlling lot average and lot standard deviation. The method applies when the characteristic used to assess lot quality is measurable and the distribution of the characteristic is adequately described by the normal distribution.

Basic Concepts

The choice of one lot acceptance sampling procedure in preference to another is primarily made on the basis of which procedure most successfully and economically discriminates between "good" and "bad" lots. Although this paper will be confined chiefly to the discussion of a variables sampling procedure for discriminating between "good" and "bad" lots, it is readily apparent that some attention must be paid to the question of "good" individual units because the concept of a "good" lot is based on "good" individual units.

The criterion governing the designation of a unit as "good" or "bad" generally takes the form of specification limits or tolerances, with the understanding that a unit on or within the specification limits is "good" while a unit outside of specification limits is "bad." The choice of the specification limits depends upon design, manufacturing, and end-use requirements. The ideal situation would occur when a unit just outside of specification limits never functions properly, while a unit on or just inside specification limits always functions properly. It is extremely common, however, to find units slightly beyond specification limits functioning just as well as units slightly inside specification limits. The situation becomes more complicated if one must consider how well a unit functions. In some cases, for example, a unit having a value at the center of the specification limits functions perfectly, but the unit is found to function less and less satisfactorily as it moves away from the center, until at some point it does not function at all.

It is somewhere in this interval, of course, that the specification limits lie. In this case, one must not only consider the question, "Does the unit function or not?" but also, "How well does the unit function?". It seems evident then that the definition of a "good" unit as "one which is on or within specification limits" is only as good as the choice of the specification limits. To the customer, a "good" unit might simply be one that functions properly in a specific application, and a "bad" unit one that does not. The customer's criterion, however, is often impossible to apply at the manufacturer's plant. For practical purposes, therefore, the definition of a "good" unit is one "on or within specification limits."

A. Lot Quality In Terms of Attributes

The problem of defining a "good" lot is a relatively simple one when attribute sampling is to be employed, because the only criterion involved is the percentage of units beyond specification limits. In this case, a

"good" lot is one whose percentage of "bad" units is equal to or less than some stated amount, generally referred to as the Acceptable Quality Level (AQL)*. The AQL, like the specification limits, should be compatible with the importance of the unit's end-use application and the capabilities of the manufacturing process.

It is not an uncommon practice to find lot quality being defined in terms of attributes even though the characteristic is measurable. This practice leads to difficulty when the definition of a "good" lot by percent defective alone is inadequate for customer needs. For example, all the frequency distributions in Fig. 1 are "good" lots if the only requirement of a "good" lot is that it contain 1.0 percent or less out-of-specification units.

Customer reaction to the receipt of the four (4) lots illustrated in Fig. 1 may vary radically, despite the fact that a specification in terms of attributes only defines them as "good" lots.

B. Lot Quality In Terms Of Variables

When the distribution of product within specification limits is important, additional requirements are needed to refine the definition of a "good" lot. One such refinement might be to require that the lot average be within some specified limits, while another refinement might be to require that lot standard deviation be less than some specified value.

If these refinements are made, a "good" lot would be defined as a lot whose parameters meet the specification requirements, i.e., percent defective less than or equal to the AQL, lot average on or within specified limits, and lot standard deviation less than or equal to a specified value.†

Because the average and the standard deviation completely describe a normal distribution, it is not necessary to specify limits for all three of the parameters mentioned above (AQL, average, and standard deviation). That is, specifying limits on the average and standard deviation imposes a limit on the lot percent defective.

Note particularly how the lots sketched in Fig. 1 would have been acted upon by a specification which restricted average and standard deviation. The results are tabulated in Table I.

A "good" lot, therefore, can be redefined as a lot whose average is on or within specified limits and whose standard deviation is less than or equal to some specified value.

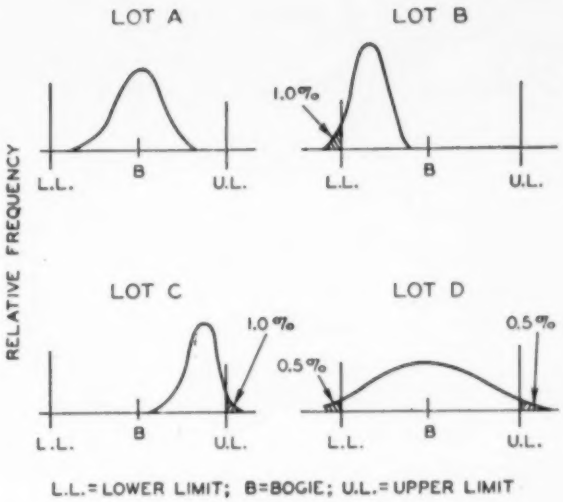


Figure 1

Statistical methods may then be applied to estimate these specified lot parameters or to reach acceptance (or rejection) decisions on submitted lots.

The Median and Quasi-Range

The Median and Quasi-Range are estimates of the average and standard deviation respectively. Hence, they can be used to evaluate a lot in terms of a given average and standard deviation specification.

A. Definitions

Median ($\tilde{X}$)

The median ($\tilde{X}$) of a set of n observations is the middle value when all values are arranged in order of magnitude. If n is an even number, the median is the average of the two middle values.

Quasi-Range (QR_i)

The i-th quasi-range (QR_i) is defined as the difference between the i-th and $(n + 1 - i)$-th reading in a sample of size n when the readings are arranged in the order of magnitude. The symbol QR_i is introduced as suggestive of quasi-range in place of the symbol (ω) used in Ref. 1.

B. Example of Determining The Median and Quasi-Range

Consider the data in three forms in Table II.

There are 35 observations. By definition, the median is the 18th ordered value and, therefore, $\tilde{X}$ equals 49 (circled on array and frequency distribu-

TABLE I

Lot	Percent Defective	Lot Average	Standard Deviation
A	OK	OK	OK
B	OK	LOW	OK
C	OK	HIGH	OK
D	OK	OK	HIGH

*Editorial Note: This statement deserves elaboration. The JETEC-11 Committee published a "Glossary of Quality Terms," JO-C7, 1953, in which AQL is defined as follows:

"The maximum percentage defective or the maximum number of defects per unit which can be considered satisfactory as a process average."

Except for "defects per unit" instead of "defects per 100 units", this agrees with the ASQC definition of AQL given in its Standard A-2, "Definitions and Symbols for Acceptance Sampling by Attributes," 1957.

The point is that a lot whose percentage of "bad" units is equal to or less than the stated AQL would simply be *by definition* a "good" lot. But lots whose true proportion defective is not significantly worse than the stated AQL may also be (and in practice *are*) regarded as "good" lots. Strictly speaking, AQL is a term that refers to the average proportion defective in the *process* from which the lot came rather than to the actual quality of *any particular* lot itself.

Also, whether a "good" lot (if presented) will be *accepted* by a sampling plan indexed to the stated AQL is quite another matter. Care must be taken *not* to confuse any *definition* of a "good" lot with the actual lot quality that a given sampling plan will pass. A sampling plan indexed by a particular value of AQL will accept lots whose percent defective is definitely greater than the specified AQL with a predicted relative frequency.

†*Editorial Note*: Here, again, it is essential to emphasize that these specifications are ways of defining a "*good*" lot—they are *not* in any sense promises as to what kind of lots a given sampling plan will *accept*.

TABLE II

Raw Data			Array			Frequency Distribution	
46	52	45	44	48	51	43	
50	47	48	44	48	51	44	xx
55	47	51	45	48	51	45	xxx
51	50	49	45	49	51	46	xxx
45	47	50	45	49	51	47	xxx
52	49	53	46	(49)	52	48	xxxx
48	48	46	46	50	52	49	xx (x)
50	51	50	46	50	52	50	xxxxxx
46	45	44	47	50	53	51	xxxxx
50	51	49	47	50	53	52	xxx
51	44	53	47	50	55	53	xx
52	48		48	50		54	
						55	x

tion). The quasi-range (QR_i) depends on i and is easily determined from the array or frequency distribution.

For i = 1, $QR_1 = 55 - 44 = 11$
For i = 2, $QR_2 = 53 - 44 = 9$
For i = 3, $QR_3 = 53 - 45 = 8$
For i = 4, $QR_4 = 52 - 45 = 7$

The first quasi-range (QR_1) is seen to be the familiar statistic Range (R).

C. The Median ($\tilde{X}$) As An Estimate Of Lot Average

The median ($\tilde{X}$), like any other sample statistic, has a frequency distribution. The frequency distribution of medians of samples from a normal population follows the normal curve and has a mean of $\bar{X}'$ (where $\bar{X}'$ is the lot average) and a standard deviation ($\sigma_{\tilde{x}}$) which is dependent upon the lot standard deviation (σ_x') and the sample size (n). Table III shows the standard deviation of the median for various sample sizes and fixed σ_x'.

TABLE III*

n	$\sigma_{\tilde{x}}$
5	0.536 σ_x'
10	0.372 σ_x'
15	0.319 σ_x'
20	0.271 σ_x'
25	0.248 σ_x'
30	0.224 σ_x'
35	0.211 σ_x'
40	0.195 σ_x'
45	0.186 σ_x'
50	0.175 σ_x'

*Values of $\sigma_{\tilde{x}}$ contributed by A. Davies, General Electric Co., Owensboro, Kentucky. (See Ref. 2 for original sources.)

When the standard deviation of the median is known, acceptance limits for medians of a particular sample size and some given specification can be computed in the same manner as limits for sample average.

For example, suppose that the following limits have been set for lot averages:

Lot Average Lower Limit = 40
Lot Average Upper Limit = 60

Further suppose that n = 35, and $\sigma_x' = 5$. Then the acceptance limits for the sample median are computed as follows:

Lower acceptance limit for $\tilde{x}$ $= 40 - 1.645\ \sigma_{\tilde{x}}$
$= 40 - (1.645)(0.211)(5)$
$= 40 - 1.74$
$= 38.26$

Upper acceptance limit for $\tilde{x}$ $= 60 + 1.645\ \sigma_{\tilde{x}}$
$= 60 + (1.645)(0.211)(5)$
$= 60 + 1.74$
$= 61.74$

where 1.645 is the normal deviate which yields a tail area of 5 percent (i.e., a lot whose average is on the upper or lower limit for lot averages has a 95 percent probability of acceptance).

D. The Quasi-Range As A Measure Of Lot Standard Deviation

The frequency distribution of the quasi-range (QR_i) is close enough to the normal distribution so that limits for sample quasi-ranges may be computed in the same manner as they were for the median, provided the mean and standard deviation of the quasi-range are known. These parameters are given by

Mean $= \overline{QR}_i = A\sigma_x'$
Standard Deviation $= \sigma'_{QR} = B\sigma_x'$

where σ_x' is the lot standard deviation and A and B are constants dependent upon n and i.

Values of A and B are shown in Table IV for the quasi-range which has the greatest efficiency for a particular sample size.

Suppose the limit for lot standard deviation has been set at $\sigma_x' \leq 5$. The acceptance limit for sample quasi-ranges are computed as follows:

Acceptance limit for $QR_i = (\overline{QR}_i + 1.645\sigma'_{QR})$
$= A\sigma_x' + 1.645(B\sigma_x')$
$= A(5) + 1.645(B)(5)$

For n = 35, Table IV shows that QR_3 should be used, A = 2.895, and B = 0.422. Using these values, the above example may be completed to yield:

Acceptance limit for QR_3 and n = 35
$= (2.895)(5) + (1.645)(0.422)(5)$
$\approx 14.5 + 3.5 = 18.0$

J. H. Cadwell, Ref. 1, has shown that for sample sizes less than n = 18, the most efficient quasi-range to use is QR_1 (ω_0 in Cadwell's notation); for sample sizes of 18 to 31 inclusive, QR_2 is the most efficient quasi-range; for sample sizes 32 to 50 inclusive, QR_3 is the most efficient quasi-range.

E. Data Recording

There has been a general tendency in all phases of industrial applications of statistics toward the use of frequency distributions in data recording. The frequency distribution is to raw data as a picture description is to a word description. Table II illustrates this. The median and quasi-range lend themselves to the frequency distribution form of recording data, and this fact has added impetus to its development and use. However, the cell interval shall be chosen in such a manner that there is a cell for every observable value. This will assure values of the median and quasi-range identical to those obtained from the raw data. Data may also be recorded in the raw data form and the criteria still applied. Thus, the median, quasi-range adds flexibility to the data recording operation involved in a variables sampling plan.

F. Example Of Applying The Median, Quasi-Range

In Sections C and D above, procedures were given for computing acceptance limits for the median and quasi-range. An example will now be given to show the procedure by which a lot is evaluated, assuming that acceptance limits are given.

Consider an electron tube type which requires a test by variables for a certain electrical characteristic known as "transconductance." The specification states that a random sample of 35 tubes per lot shall be measured for this characteristic and the following tests by variables made:

1. Test for lot average—the median of the sample must be on or within acceptance limits of 4550 and 5450 micromhos (units of transconductance).

2. Test for lot standard deviation—the 3rd quasi-range (QR_3)—must be less than or equal to 1235 micromhos.

The following measurements represent a random sample for the lot under test. Measurements were made to the nearest 50 micromhos.

5450	4650	5100	5650	5300	5400	5400
5050	5850	5500	5100	5650	4950	5750
5500	6150	5100	4800	4950	5250	5000
5650	5600	5450	5700	5350	4950	5250
6050	4500	5550	5550	4700	4850	5550

TABLE IV

n	Quasi-Range (QR_i)	A (QR_i/σ_x')	B (σ'_{QR_i}/σ_x')
5	QR_1	2.326	0.864
10	QR_1	3.078	0.797
15	QR_1	3.472	0.756
20	QR_2	2.815	0.538
25	QR_2	3.049	0.522
30	QR_2	3.231	0.509
35	QR_3	2.895	0.422
40	QR_3	3.034	0.414
45	QR_3	3.153	0.407
50	QR_3	3.257	0.401

*Values of A and B for QR_3 in Table IV contributed by Dr. M. Sobel of the Bell Telephone Laboratories, Allentown, Pa. Those for QR_1 are simply the d_2 and d_3 values from Ref. 3. Those for QR_2 are from Ref. 1.

These 35 measurements were recorded in order of magnitude as shown in Table V by marking an "X" for each measurement on the prepared scale.

The median is the middle measurement in the sample so arranged. In a sample of 35, the median is the 18th measurement. Counting to the 18th measurement, one finds the median, $\tilde{X} = 5400$, which is circled. This median is within the acceptance limits of 4550 and 5450, so the lot is acceptable for lot average.

Counting in from each end of the ordered arrangement, one finds the 3rd highest measurement to be 5850, and the 3rd lowest to be 4700. Then $QR_3 = 5850 - 4700 = 1150$. This value of the quasi-range is less than the acceptance limit of 1235, so the lot is acceptable for lot standard deviation.

References

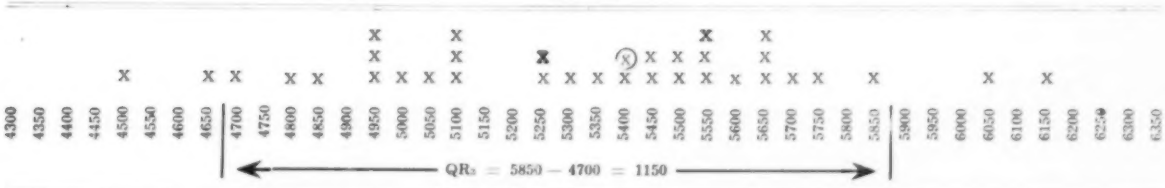
(1) Cadwell, J. H., "The Distribution of Quasi-Ranges in Samples from a Normal Population," *The Annals of Mathematical Statistics*, Vol. 24, No. 4, Dec. 1953

(2a) Hojo, Tokishige, "Distribution of the Median, Quartiles, and Inter-Quartile Distance in Samples from a Normal Population," *Biometrika*, Vol. XXIII, 1931, p. 315-360

(2b) Pearson, Karl and Margaret V., "On the Mean Character and Variance of a Ranked Individual, and on the Mean and Variance of the Intervals Between Ranked Individuals," *Biometrika*, Vol. XXIII, 1931, p. 364-397

(3) *ASTM Manual on Qualty Control of Materials*, Table B2, p. 115

TABLE V



Plotting Experimental Data *on Normal or Log-Normal Probability Paper*

ENOCH B. FERRELL

Bell Telephone Laboratories, Inc., Murray Hill, N. J.

Abstract

This article considers the plotting of experimental results on probability paper. The i-th observation—in order of magnitude—in a sample of n is plotted at i/(n+1) on the frequency scale. A smooth curve having the properties of the median is fitted to the plotted points. The dispersion is estimated from the 6.68 and 93.32 percentiles on the smooth curve, which give a partial range of 3σ.

These procedures are used also with skewed distributions which can be approximated by the Log-Normal distribution.

Introduction

Arithmetic probability paper (Codex Book Company No. 3127) is a graph paper used for plotting cumulative frequency distribution as a function of the variate. The frequency scale is so designed that if any Normal distribution is plotted on it, the resultant curve is a straight line. The use of probability paper in the study of experimental data usually involves three steps: plotting the observations, drawing a smooth curve through the plotted points, and reading some central value and some measure of dispersion from the smooth curve.

This article describes those three steps. It also describes the use of logarithmic probability or Log-Normal paper for representing distributions that are badly skewed. It proposes a measure of dispersion that may be more useful than the usual standard deviation in connection with these skewed distributions.

Plotting the Data

In plotting the data it is highly desirable to use original observations—not some modified or lumped data and not some frequency count. Consider as an example the 32 observations given in Table I. These numbers are the batting averages of members of the two champion baseball teams of 1951—Yankees and Giants. They are arranged here in ascending order of magnitude. This arrangement has lost valuable information about possible correlation with age, service, type of training, or any other independent parameter. It is inherent in any simple distribution study that it ignores such information.

The smallest reading is x_1=232. We will plot it at 232 on the batting average scale and 3.03 percent on the frequency scale. To get the 3.03 percent we divide 1, the number of the reading, by 33 which is one more than the sample size. The general rule is that we plot the i-th reading in a sample of n at i/(n+1) on the frequency scale. We plot the second reading at 6.06 percent. And so on. The largest reading x_{32} = 375 is plotted at 96.97 percent. (See Fig. 1.)

To justify this rule, note that we are not in doubt as to the value of the 232 or the 375. It is the frequency that is uncertain. The things we do not know are the positions of these values, 232 and 375, in the cumulative frequency distribution of the universe from which this sample was drawn.

Consider, for example, the largest member of the sample. If we should go through life examining the largest members of samples of 32, we would find them sometimes at one point on their parent distribution, and sometimes at another. In practice we never know just where they belong. We would like to have an estimate of their position—an estimate that we could always use with the knowledge that on the average we would be right. We want an unbiased estimate of the position, in the parent distribution, of the largest member of a random sample of n.

The cumulative density function, the c.d.f., F, is the probability that some number, X, drawn at random from the population is equal to or smaller than some stated value, x.

$$F = \Pr\ (X \leq x)$$

If we draw a random sample of n from this population, the probability that all n are equal to or less than x is

$$\Pr\ (\text{All } X \leq x) = F^n$$

Now the probability that all are equal to or less than x is just the probability that the largest one, X_n, is equal to or less than x.

$$\Pr\ (X_n \leq x) = F^n$$

That is, F^n is the cumulative distribution of the largest in a sample of n. We want the mean of this last dis-

TABLE I—Batting Averages

232	263	277	298
235	266	281	300
235	267	281	303
247	269	286	306
255	273	294	312
259	273	294	317
259	274	294	320
262	274	296	375

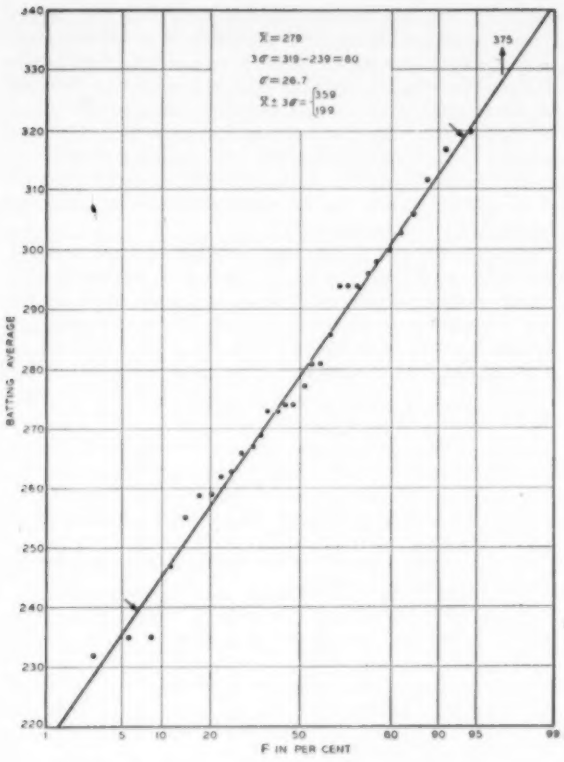


Figure 1—Batting Averages on Arithmetic Probability Paper

tribution, F^n. We must find its probability density function, which is the derivative of its cumulative function:

$$nF^{n-1}$$

The mean is the integral of the product of value and density.

$$\bar{F}(x_n{:}n) = \int_0^1 FnF^{n-1}dF.$$

We might read $\bar{F}(x_n{:}n)$ as the mean position, in the parent cumulative distribution, of the n-th, i.e., the largest, in a sample of n. Since a cumulative function has values only between 0 and 1 inclusive, these are our limits of integration.

$$\bar{F}(x_n{:}n) = nF^{n+1}/(n+1)\Big]_0^1$$
$$= n/(n+1)$$

That is, on the average the n-th member, numbered from the smallest, in a sample of n, is located at the $n/(n+1)$-th fractile of the distribution—$n/(n+1)$ of the way up from the bottom. Note that we are not discussing the value of the variate x. We are studying the cumulative frequency, F, in the parent distribution.

By a similar kind of proof it can be shown that on the average the i-th member of the sample is $i/(n+1)$ of the way up from the bottom in the distribution. (See, for example, *Introduction to the Theory of Statistics*, A. M. Mood, p. 387.) Intuitively, if the largest member is $n/(n+1)$ of the way up from the bottom, it is $1/(n+1)$ of the way down from the top; and by symmetry the smallest member is $1/(n+1)$ of the way up from the bottom.

Note two interesting things: First, we have not said whether the parent distribution is Normal, or skewed, or exponential or anything else. The rule is completely independent of the shape of the parent. This is because we are dealing with order statistics. Second, if we divide the whole frequency scale from 0 to 100 percent into n+1 equal parts, we have just n equally spaced division points in between the end points. This is where the members of the sample belong on the average, and this avoids any question about plotting one of the end points off at infinity.

To get back to our example: We plot the smallest of 32 at 3.03 percent, the next at 6.06 percent, and so on. On the graph paper we need to draw a dot that is big enough to be read from across the table. But on the usual probability paper, such a dot has a diameter larger than the space between 3.00 and 3.03 percent. So we might as well put the first dot at 3 percent, the second at 6 percent, and so on. If we keep this up, we find we are plotting the 16-th point at 48 percent when we should be plotting it at 48.5 percent. On most of our probability paper, this error is still less than the diameter of an easily read dot. To avoid further error, however, we now start at the top end, with the largest reading, and work down—again using the round-numbered 3 percent points.

This willingness to do a little round-numbering, to work in from each end and leave the irregularity in the middle, invites us to use samples of 20, 24, 32, 40, 48, 64 or 100, which are easily broken up into subgroups of 4 for control chart work, or to use samples of 20, 25, 40, 50, or 100 which are easily broken up into subgroups of 5.

In plotting members of a sample of 64, the first should be at 1.54 percent and the second at 3.07 percent. We would probably skip the first one, plot the second at 3 percent, and then plot the alternate ones at the 3 percent points. Similarly if we had 800 readings, we might plot every 16-th one at the 2 percent points or every 24-th one at the 3 percent points.

In using this method we always work from each end until we have used half the data, even if this takes us beyond the middle of the paper. We always plot until we reach the middle of the paper, even if this takes us past the middle of the data. That is, we keep plotting until we have satisfied both these requirements. This may give us what looks like extra points near the 50 percent line. But this congestion tends to be symmetric and merely emphasizes the position of the median.

If we are forced to use frequency count data, we can plot only the cell boundaries. Sometimes we know the cell centers and not the cell boundaries. If we are told that the 30 smallest readings in a sample of 900 are in a cell centered at 15, and that the next 171 are in a cell centered at 30, we can guess the following: The cell boundary is at 22.5. The largest of the 30 is only slightly smaller than 22.5. The smallest of the 171 is only slightly larger than 22.5. In loose language, the 30.5-th reading is very close to 22.5. So we plot a point at 22.5 and $30.5/901 = 3.4$ percent.

Since we are considering frequency as the unknown function of the known variate, it would be logical to plot frequency on the vertical scale and variate on the horizontal scale. The Codex paper is printed in such a way as to invite us to reverse this and make the frequency scale horizontal. Many engineers do this and we will use this convention here.

Fitting the Curve

Our second problem is to draw a smooth curve through the points. Let us try a straight line first. Lay

a straight line—the edge of a draftsman's triangle—at what looks like a good fit. Hold this line at a point near the smallest reading and swing the line about this point as a pivot, until the line bisects the far half of the data. That is, for our 32 point sample, rotate the line until 8 of the 16 largest readings are above the line and the other 8 of those 16 largest readings are below the line. Without actually drawing this line, shift the pivot to the top end of the line, to a point on the line near the largest reading, and swing the line until it bisects the lower half of the data. Then shift the pivot back to the lower end and correct the top end again. Each of these shifts improves the fit of the line, but usually only two or three are needed to get a satisfactory fit.

This line has the properties of a median in that it divides the data into equal parts, half above and half below, and in that it tends to minimize the mean deviation from itself. It may differ from the "least squares" line which minimizes the root-mean-square deviation.

If we look upon this median line that we have just established and the 50 percent line on the probability paper as a pair of oblique axis, we have now divided the field into four sectors which correspond to quadrants; and we have exactly the same number of points in each sector. In this sense, which is the sense of tetrachoric correlation, our fitted line now displays all the correlation that exists between frequency and variate. In this sense it is a best fit.

Testing the Curve

We can test the goodness of this fit by looking at the runs above and below the line. A run is a sequence of consecutive points on one side of the line. If the total number of runs—runs above and runs below together—is less than

$$n/2 + 1 - \sqrt{n-1}$$

or if the longest run contains more than 8 points, we can be fairly sure that our line is not a good fit. A curve should be used. We can then use a French curve or a ship's curve that looks about right. We fit this by the same method and test its fit by examining the runs in the same way. (For a discussion of runs see "Runs Determined in a Sample by an Arbitrary Cut," P. S. Olmstead, *Bell System Technical Journal*, January 1958.)

Alternatively, we might break the plotted data into two or three sections and fit each with a segment of straight line. Each of these sections should contain at least 12 or 15 points.

Estimating Central Value and Dispersion

Our final problem is to read a central value and a dispersion from our fitted curve. The intersection of our line with the 50 percent line gives us the median at once. If the distribution is symmetric, the median should be the same as the mean. The averaging that we have done in fitting the line has improved the efficiency of this estimate over that of the simple sample median, and it is perhaps as good an estimate as is possible with any graphical method.

It is customary to get the dispersion, for a Normal distribution that is represented by a straight line on arithmetic probability paper, from the 16 and 84 percent points. These correspond to $\bar{x} \pm \sigma$. Half the partial range between these two values of the variate is an estimate of σ.

It has been shown that the most efficient partial range estimate of σ is obtained, not by using the 16 and 84 percentiles, but by using points at 6.94 percent and 93.06 percent. This assumes a Normal parent. (See "Some Useful Inefficient Statistics," Mosteller, *Ann. Math. Stat.*, Dec. 1946.) It has been observed empirically that something in the neighborhood of 6 or 7 percent and 93 or 94 percent seems to make us least dependent on the shape of the parent. It is recommended, therefore, that we use the points 6.68 percent in from each end. The resultant partial range is, for the Normal universe, just 3σ. It is approximately 3σ for several other universes of widely different shapes.

In addition to high efficiency—helped by the averaging effect of the smooth curve—and low dependence on parent shape, this particular partial range gives us directly an estimate of the 3σ which we use so much in setting control limits and tolerances.

From Fig. 1 we estimate

Median, or mean	$\bar{x} = 279$
Dispersion:	$3\sigma = 319 - 239 = 80$
	$\sigma = 80/3 = 26.7$
Three-sigma limits:	$279 \pm 80 = 199$ and 359

The only reading outside these limits is 375 for a batter who was at bat only 8 times.

For comparison, the usual "best estimates" give

$$\bar{x} = 280$$

$$\sigma = 29.4$$

It seems apparent that these are considerably influenced by the one reading of 375.

Skewed Distribution and Log-Normal Paper

Sometimes we find that to get a good fit we must use a line that is quite curved. There may be many small readings but none negative. The large readings may be well spread out with a few that are very large. If we try to fit a straight line to the data, we get long runs above the line at each end and a long run below the line in the middle.

If we were to use a logarithmic scale for the variate, we would pull both ends of the curve down and tend to straighten it. Often the straightening is quite good. This means that the logarithms of our readings represent a Normal or near-Normal universe. We say the readings themselves represent a Log-Normal universe. We have graph paper whose variate scale is logarithmic, and whose frequency scale is the same as on the arithmetic probability paper. If we plot a Log-Normal distribution on it, we get a straight line. This paper is called logarithmic probability paper, or simply Log-Normal paper. It is Codex Book Company's No. 3128.

In plotting data on Log-Normal paper we use the same rule as before: We plot the i-th reading at $i/(n+1)$ on the frequency scale.

The curve fitting technique is exactly the same.

It seems likely that we should be interested in estimating something different. The value of the variate at which the curve crosses the 50 percent line is still a good estimate of the median. But it is no estimate of the arithmetic mean. It is, however,—if the line is straight—a good estimate of the geometric mean. This geometric mean is the n-th root of the product of all n readings. We usually compute the geometric mean as the antilogarithm of the mean of the logarithms. But for a Log-Normal universe the mean of the logarithms and the median of the logarithms should be the same. Hence, we use the antilogarithm of the median of the logarithms as an estimate of the geometric mean.

Now if one number is larger than a second, the logarithm of the first is larger than the logarithm of the second. If we arrange either the readings or their logarithms in order of magnitude, then the other is also in order. Hence the antilogarithm of the median of the logarithms is the median of the readings themselves. We can read it directly at the 50 percent point on our smooth curve. This gives us an estimate of the geometric mean with no further computation.

Similarly, if we should read the value of the variate at the 6.68 and 93.32 percent points, convert to logarithms, subtract and divide by 3, we would have an estimate of the standard deviation of the logarithms. The antilogarithm of this sigma of the logarithms is not the standard deviation of the experimental observations. But it may be a more useful measure of dispersion. We will call it the geometric dispersion, g.

In our ordinary work we often set limits at "the mean plus or minus 3σ". These are symmetric limits suitable for a symmetric universe. Now the logarithms of a Log-Normal universe form a universe of their own that is symmetric. It is quite logical to place symmetric limits on the logarithms at their mean plus or minus three times their sigma.

But when we convert back to pounds or inches, this gives us limits at "the geometric mean times or divided by g^3." This g is the antilogarithm of the standard deviation of the logarithms—the geometric dispersion we mentioned above. This g serves the same role in the Log-Normal universe as σ serves in the Normal universe. Roughly two-thirds of a Log-Normal universe lies within the limits $\tilde{x}g^{\pm 1}$. Roughly 95 percent lies within the limits $\tilde{x}g^{\pm 2}$. Approximately 0.13 percent lies in each tail outside the limits $\tilde{x}g^{\pm 3}$. Here we are using the median, $\tilde{x}$, when we should be using the geometric mean. There are two reasons for this: We propose to estimate the geometric mean by locating the median. We have a fairly well recognized symbol for the median, $\tilde{x}$.

To estimate this g we find the 6.68 percent and 93.32 percent points on the cumulative distribution curve that we have drawn; we take their ratio—not their difference; and we take the cube root of that ratio—we do not divide it by 3.

Our estimating procedure now becomes, in principle and almost in detail, the same for the Log-Normal universe as for the Normal universe.

As an example, consider the data in Table II. The variate here is a particular current in a certain set of transistors, measured under certain conditions. There are 50 transistors. In Fig. 2 we have plotted the alternate readings, beginning with the second and forty-ninth, at the 4 percent points on Log-Normal paper. We get a reasonably good fit with a straight line.

From this we estimate the median, or geometric mean:

$$\tilde{x} = 95.$$

The dispersion:

$$g^3 = 1200/8 = 150$$

$$g = 5.3$$

Three-sigma limits:

$$95 \cdot 5.3^{\pm 3} = 0.63 \text{ and } 14200$$

These limits, as we might have hoped, include the extreme readings, 2 and 8000.

TABLE II—Transistor Current

2	30	100	300
6	40	100	400
7	40	100	400
8	40	126	500
8	50	130	500
14	50	140	500
18	50	150	600
21	60	160	700
22	60	200	700
22	60	300	1200
26	60	300	1700
30	70	300	8000
	90	300	

For comparison, the usual "best estimates", based on the actual readings give

$$\bar{x} = 376$$

$$\sigma = 1158$$

$$\bar{x} \pm 3\sigma = -3098 \text{ and } 3850$$

Although only one of the readings lies outside these limits, it is still apparent that this arithmetic description gives no very useful picture of the distribution.

Note that with a badly skewed universe such as the Log-Normal, the ideas of $\bar{x}$, σ and differences are more or less meaningless if not misleading; but the ideas of $\tilde{x}$, g and ratios have just the significance we normally associate with the mean, sigma and difference.

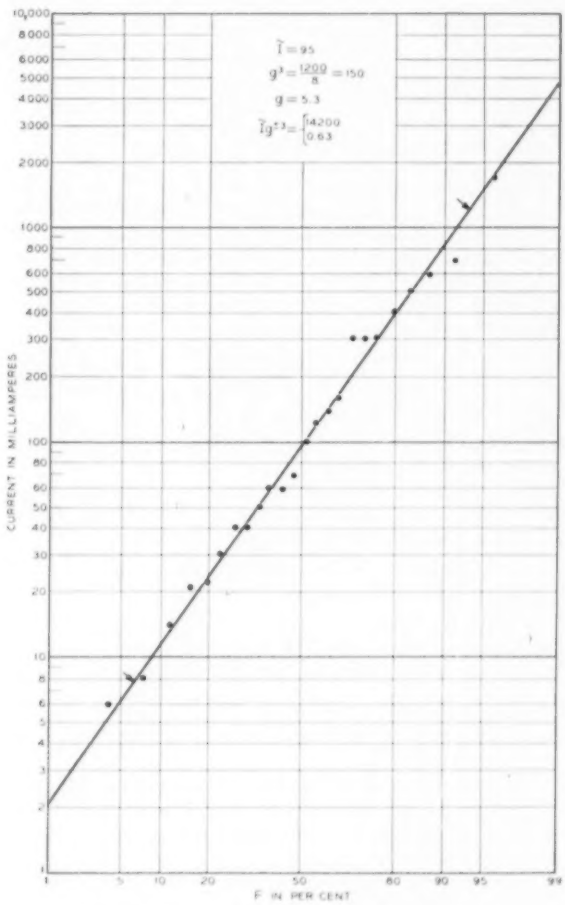


Figure 2—Transistor Current on Log-Normal Paper

Determination of Optimum Operating Conditions by Experimental Methods

Part I

Mathematics and Statistics Fundamental to the Fitting of Response Surfaces*

RALPH ALLAN BRADLEY

Virginia Polytechnic Institute, Blacksburg, Va.

Introduction

There has been an interesting acceptance of the methods of fitting response surfaces and of locating optimum operating conditions developed by Box and Wilson and later by Hunter and others. These research workers have made a very important contribution to the theory, application, and philosophy of statistics. Their main contributions are in the interpretation of experimental results, a new look at experimental data. We shall indicate that the methods are largely based on the theory of multiple regression. This theory has, however, been simplified in application through the use of special experimental designs particularly suitable for the investigation of response surfaces.

An understanding of what we shall call the Box-Wilson techniques must be based on knowledge of the following topics in mathematics and statistics:

1. The theory of multiple regression and its specialized form in the analysis of variance.

2. Special features of factorial designs, particularly the 2^n series, including the principles of single degrees of freedom, confounding, and fractional replicates.

3. The theory of maxima and minima in several variables and methods of obtaining paths of steepest ascent or descent.

4. The theory of multi-dimensional conics in geometry. It is our intention to deal briefly with these subjects here as an introduction to the companion paper by Dr. Hunter which will appear in a subsequent issue of *Industrial Quality Control*.

*Presented at the Rutgers Conference on Quality Control, September 10, 1955, as part of a program on "Determination of Optimum Operating Conditions by Experimental Methods." A companion paper was presented by Dr. J. S. Hunter, and a revision and expansion of this paper will appear in a later issue of *Industrial Quality Control*.

Multiple Regression

Consider a true functional relationship between a response η and factors, $x_1, \ldots, x_p$, affecting that response as given by

$$\eta = \beta_0 + \beta_1 x_1 + \ldots + \beta_p x_p. \qquad (1)$$

$x_1, \ldots, x_p$ are regarded as fixed or non-stochastic variables or settings and $\beta_0, \ldots, \beta_p$ are parameters to be estimated. $x_1, \ldots, x_p$ need not be functionally independent and in fact we could have $x_i = g_i(u_1, \ldots, u_q)$ where the u's are then variables determining the x's. For example, in some cases we may wish to have $x_1 = u$ and $x_2 = u^2$. Thus the model (1) includes curvilinear regression.

Let y_α be the α^{th} of N observations on η with x_i having the value $x_{i\alpha}$, $i = 1, \ldots, p$. y_α is a variate and regression theory supposes that

$$y_\alpha = \beta_0 + \beta_1 x_{1\alpha} + \ldots + \beta_p x_{p\alpha} + \varepsilon_\alpha \qquad (2)$$

where ε_α is a random variable satisfying the conditions:

(i) ε's are normal.

(ii) ε's have zero means, $E(\varepsilon_\alpha) = 0$, $\alpha = 1, \ldots, N$.

(iii) ε's are independent, $E(\varepsilon_\alpha \varepsilon_\gamma) = 0$, $\alpha \neq \gamma$, $\alpha, \gamma = 1, \ldots, N$.

(iv) ε's have homogeneous variances, $E(\varepsilon_\alpha^2) = \sigma^2$, $\alpha = 1, \ldots, N$.

Let b_i be an estimate of β_i, $i = 0, 1, \ldots, p$. These estimators are obtained by least squares through minimizing

$$\sum_{\alpha=1}^{N} (y_\alpha - \beta_0 - \beta_1 x_{1\alpha} - \ldots - \beta_p x_{p\alpha})^2 \qquad (3)$$

through partial differentiation with respect to the β's and with the b's representing the solution of the resulting (p+1) linear equations in (p+1) unknown β's. It is found that

$$b_0 = \bar{y} - b_1\bar{x}_1 - \ldots - b_p\bar{x}_p \qquad (4)$$

and that

$$b_i = c_{i1}g_1 + \ldots + c_{ip}g_p, \; i = 1, \ldots, p \qquad (5)$$

where

$$a_{ij} = \sum_{\alpha=1}^{N} (x_{i\alpha} - \bar{x}_i)(x_{j\alpha} - \bar{x}_j), \; i, j = 1, \ldots, p, \qquad (6)$$

$$g_i = \sum_{\alpha=1}^{N} (x_{i\alpha} - \bar{x}_i)(y_\alpha - \bar{y}), \; i = 1, \ldots, p \qquad (7)$$

and

$$[c_{ij}] = C = A^{-1} = [a_{ij}]^{-1}, \qquad (8)$$

the latter in matrix notation. The matrix whose elements are c_{ij} is then the matrix representing the inverse of the p by p matrix with elements given by (6).

$\bar{y} = \left(\sum_{\alpha=1}^{N} y_\alpha\right)/N$ and $\bar{x}_i = \left(\sum_{\alpha=1}^{N} x_{i\alpha}\right)/N$, $i = 1, \ldots, p$. The difficulty in applying regression theory stems from the need of inverting the matrix A.

The difficulty is missed in the special case where all values $a_{ij} = 0$ for $i \neq j$ and this is true in the analysis of variance, as we shall see later. If most values $a_{ij} = 0$, the difficulties are reduced. Some of the designs for response-surface fitting have all values $a_{ij} = 0$ and others have most of these quantities zero.

An estimate s^2 of σ^2 [see (iv) above] with $(N - p - 1)$ degrees of freedom is obtained by computing

$$s^2 = \frac{1}{N-p-1}\left[\sum_{\alpha=1}^{N} (y_\alpha - \bar{y})^2 - \sum_{i=1}^{p}\sum_{j=1}^{p} c_{ij}g_ig_j\right]. \qquad (9)$$

The variance of b_i is

$$V(b_i) = c_{ii}\sigma^2, \; i = 1, \ldots, p \qquad (10)$$

and the variance of the difference, $b_i - b_j$, is

$$V(b_i - b_j) = (c_{ii} - 2c_{ij} + c_{jj})\sigma^2, \; i \neq j, \; i, j = 1, \ldots, p. \qquad (11)$$

Estimated variances follow from the substitution of s^2 in (9), in (10), and in (11). Tests of hypotheses are possible. Given Ho: $\beta_i = \beta_i^0$, β_i^0, a specific value of β_i, usually zero, compute

$$t = \frac{b_i - \beta_i^0}{\sqrt{c_{ii}}\, s} \text{ with } (N-p-1) \text{ degrees of freedom.} \qquad (12)$$

Given Ho: $\beta_i = \beta_j$, compute

$$t = \frac{b_i - b_j}{\sqrt{c_{ii} - 2c_{ij} + c_{jj}}\, s} \qquad (13)$$

again with $(N-p-1)$ degrees of freedom.

TABLE I

Source of Variation	degrees of freedom	sum of squares
Reduction due to regression	p	$\sum_{i=1}^{p} b_i g_i$
About regression (error)	$N - p - 1$	$\sum_{\alpha=1}^{N} (y_\alpha - \bar{y})^2 - \sum_{i=1}^{p} b_i g_i$
Total	$N - 1$	$\sum_{\alpha=1}^{N} (y_\alpha - \bar{y})^2$

t in (12) or (13) is judged for significance in the usual way with tables of the Student t distribution.

Analysis of variance for regression is often used in the form given in Table I. It is to be noted that

$$R^2 = \sum_{i=1}^{p} b_i g_i / \sum_{\alpha=1}^{N} (y_\alpha - \bar{y})^2 \qquad (14)$$

where R is the multiple correlation coefficient.

Table I may be further subdivided as illustrated in Table II. Suppose the first m, $m < p$, independent variables are used in a form analogous to (1) and estimates $b_1', \ldots, b_m'$ are obtained. That is, the regression problem is first worked through ignoring the last $(p - m)$ variables. Then it is reworked including all p independent variables. The analysis of variance is given in Table II.

Analysis of Variance for Factorials

Consider a factorial arrangement of treatments in complete blocks. We shall limit this consideration to a 2^3 factorial since the salient points can be illustrated in this simple case and generalizations will be obvious. It is our primary objective here to show that the usual analysis for the factorial can be associated with the discussion of the previous section.

For three factors, A, B, C, each at two levels, it is customary to describe the eight resultant treatment combinations as

(1) a b ab c ac bc abc.

The presence of a letter indicates the higher level of the corresponding factor. Yields on the analysis of variance are associated with the response y in regression. We shall assume that the three-factor interaction is absent for our purposes and consider only a single replicate.

The usual analysis of variance model may be written

$$y_{ijk} = \mu + \alpha_i + \bar{\beta}_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\bar{\beta}\gamma)_{jk} + \varepsilon_{ijk} \qquad i, j, k = 1, 2. \qquad (15)$$

TABLE II

Source of Variation	degrees of freedom	sum of squares
Reduction due to $x_1, \ldots, x_m$	m	$\sum_{i=1}^{m} b_i g_i$
Additional reduction due to $x_{m+1}, \ldots, x_p$	$p - m$	$\sum_{i=1}^{p} b_i g_i - \sum_{i=1}^{m} b_i g_i$
About regression (error)	$N - p - 1$	$\sum_{\alpha=1}^{N} (y_\alpha - \bar{y})^2 - \sum_{i=1}^{p} b_i g_i$
Total	$N - 1$	$\sum_{\alpha=1}^{N} (y_\alpha - \bar{y})^2$

Restrictions on the model are that

$$\alpha_1 + \alpha_2 = 0,$$
$$\bar{\beta}_1 + \bar{\beta}_2 = 0,$$
$$\gamma_1 + \gamma_2 = 0,$$

$$\sum_{i=1}^{2}(\alpha\bar{\beta})_{ij} = \sum_{j=1}^{2}(\alpha\bar{\beta})_{ij} = 0,$$

$$\sum_{i=1}^{2}(\alpha\gamma)_{ik} = \sum_{k=1}^{2}(\alpha\gamma)_{ik} = 0,$$

and

$$\sum_{j=1}^{2}(\bar{\beta}\gamma)_{jk} = \sum_{k=1}^{2}(\beta\gamma)_{jk} = 0.$$

The assumptions on ε_{ijk} parallel those given for ε_a in (i) to (iv).

The factorial can be related to regression by defining variables u_1, u_2, u_3 having values -1 or 1 with $u_1 = -1$ when indicating the lower level of factor A and $u_1 = 1$, the higher level of factor A, etc. The complete association is given in Table III.

The regression variables are defined by taking

$$x_1 = u_1 \qquad x_3 = u_3 \qquad x_5 = u_1u_3$$
$$x_2 = u_2 \qquad x_4 = u_1u_2 \qquad x_6 = u_2u_3. \qquad (16)$$

Now, for example, β_1 in regression corresponds to $(\alpha_1 - \alpha_2)$ in analysis of variance, β_0 with μ, and so on. The data for regression for a single replicate of the 2^3 factorial are given for x_1 to x_6 in Table IV. Note now that $N = 8$,

$$N\bar{x}_i = \sum_{a=1}^{N} x_{ia} = 0, \; i = 1, \ldots, 6,$$

$$\sum_{a=1}^{N} x_{ia}x_{ja} = 0, \; i \neq j, \; i, j = 1, \ldots, 6,$$

and

$$\sum_{a=1}^{N} x_{ia}^2 = 8, \qquad i = 1, \ldots, 6.$$

Now $a_{ij} = 8$, $i = 1, \ldots, 6$ and $a_{ij} = 0$, $i \neq j$, $i, j = 1, \ldots, 6$. The elements of the inverse matrix are simply $c_{ii} = \frac{1}{8}$, $i = 1, \ldots, 6$, and $c_{ij} = 0$, $i \neq j$, $i, j = 1, \ldots, 6$. Substitution in (7) and then (5) yields, for example,

$$g_1 = -y_1 + y_a - y_b + y_{ab} - y_c + y_{ac} - y_{bc} + y_{abc}$$

and

$$b_1 = \tfrac{1}{8}g_1.$$

TABLE III—Association of Analysis of Variance and Regression

Treatment Combination	u_1	u_2	u_3
(1)	−1	−1	−1
a	1	−1	−1
b	−1	1	−1
ab	1	1	−1
c	−1	−1	1
ac	1	−1	1
bc	−1	1	1
abc	1	1	1

TABLE IV—Regression Variables for the 2^3 Factorial

	x_1	x_2	x_3	x_4	x_5	x_6
(1)	−1	−1	−1	1	1	1
a	1	−1	−1	−1	−1	1
b	−1	1	−1	−1	1	−1
ab	1	1	−1	1	−1	−1
c	−1	−1	1	1	−1	−1
ac	1	−1	1	−1	1	−1
bc	−1	1	1	−1	−1	1
abc	1	1	1	1	1	1

The t test of the hypothesis that $\beta_1 = 0$ or $\alpha_1 = \alpha_2$ depends on

$$t = \frac{b_1}{\sqrt{\frac{1}{8}}\,s} \quad \text{and} \quad F = \frac{8b_1^2}{s^2}$$

with 1 and 1 degrees of freedom. Note that $8b_1^2$ or $(\frac{1}{8})g_1^2$ is precisely the contribution of the single degree of freedom comparison for the A-factor to the total sum of squares in the analysis of variance. Through the selective choice of values of $x_1, \ldots, x_6$, $b_i' = b_i$, $i = 1, \ldots, m$ as defined in Table II. The complete analysis of variance for the factorial in regression notation is given in Table V.

The special selection of $x_1, \ldots, x_6$ has simplified the regression analysis. Designs for the fitting of a response surface utilize some aspects of this simplification. To represent a surface, a quadratic form is generally used. Then the response function or the regression function in the three-factor case has the form

$$\eta = \beta_0 + \beta_1u_1 + \beta_2u_2 + \beta_3u_3 + \beta_4u_1u_2 + \beta_5u_1u_3 + \beta_6u_2u_3 + \beta_7u_1^2 + \beta_8u_2^2 + \beta_9u_3^2. \qquad (17)$$

To estimate the regression coefficients here, more observations are required than in the 2^3 factorial. Designs for fitting response surfaces in this case augment the 2^3 design we have discussed by additional points carefully selected to preserve at least some of the orthogonality features of analysis of variance.

Fractional Replicates

Use is made of fractional replicates of factorial designs in the fitting of response surfaces. A good discussion is given by Davies[1] and we shall consider only a half-replicate of the 2^3 factorial as an example.

Suppose only the first four observations corresponding to the first four rows of Table IV are available as a half-replicate of the 2^3 factorial. Now certain effects are confounded. Note that $x_1 = -x_5$, $x_2 = -x_6$, $x_3 = -1$ and $x_4 = -u_1u_2u_3$ for all four observations. This implies that both the AB and ABC interactions must be non-existent if we are to have a valid estimate of error based on the ABC interaction as used in the preceding section.

In the half-replicate we can only fit the regression equation

$$\eta = (\beta_0 - \beta_3) + (\beta_1 - \beta_5)x_1 + (\beta_2 - \beta_6)x_2. \qquad (18)$$

In the terminology of the analysis of variance, the defining contrast for the half-replicate is $I = -C$ and the A-factor effect is confounded with the AC interaction, the B-factor with the BC interaction, no estimate of the C-factor is available, and the AB interaction confounded with the ABC interaction combines to form an estimate of error on the assumption that neither interaction exists.

In the fitting of response surfaces, general quadratic forms like (17) are compressed to forms like the trivial

case given in (18) through the use of fractional replications. The effect is the same as that in (18) although it is clear that the half-replicate design yielding (18) is of very doubtful usefulness.

Maxima and Minima for Second Degree Polynomials

The calculation of the maximum (or minimum) response on a response surface, if a real maximum exists, may be done in terms of the design variables or on the scale of the original levels chosen for the factors and from the regression equation in the form (17) or in reduced canonical form (to be discussed later) as estimated from the experimental data. In general we may consider forms like (17) using techniques of differential calculus.

Critical values of u_1, u_2, and u_3 to be examined for optimum properties are obtained by differentiating (17) partially with respect to each variable in turn and setting the resultant partial derivative equal to zero. For (17) we have

$$\begin{aligned} \beta_1 + 2\beta_7 u_1 + \beta_4 u_2 + \beta_5 u_3 &= 0 \\ \beta_2 + \beta_4 u_1 + 2\beta_8 u_2 + \beta_6 u_3 &= 0 \\ \beta_3 + \beta_5 u_1 + \beta_6 u_2 + 2\beta_9 u_3 &= 0. \end{aligned} \tag{19}$$

The resultant solution for u_1, u_2, u_3 may be checked to see if they yield a maximum, minimum or col by an evaluation of a determinant based on second-order partial derivatives of (17). Usually this will not be necessary and the nature of the surface for these critical values will be obvious.

The Path of Steepest Ascent

In searching for conditions for an optimum response, it often happens that initial experimentation is done under conditions far from optimum. Accordingly, very often a first degree regression function is calculated based on the initial experimentation with a view to determining the direction in which to change the independent variables in order to increase the response as rapidly as possible. In general, for a response $\eta(u_1,\ldots,u_p)$, we require the direction cosines of a direction S such that $d\eta/dS$ is a maximum.

Corresponding to (17), suppose that an initial regression $\eta = \beta_0'' + \beta_1'' u_1 + \beta_2'' u_2 + \beta_3'' u_3$ has been estimated. The direction cosines of the direction S should now be proportional to β_1'', β_2'' and β_3'' respectively. This implies that changes in u_1, u_2 and u_3 should be proportional to these direction cosines.

TABLE V

Source of Variation	degrees of freedom	sum of squares
A-factor (reduction due to x_1)	1	$8b_1^2$
B-factor (additional reduction due to x_2)	1	$8b_2^2$
C-factor (additional reduction due to x_3)	1	$8b_3^2$
AB interaction (... due to x_4)	1	$8b_4^2$
AC interaction (... due to x_5)	1	$8b_5^2$
BC interaction (... due to x_6)	1	$8b_6^2$
Error (about regression), (ABC interaction)	1	S^2 (by subtraction)
Total	7	$\sum_{\alpha=1}^{8} (y_\alpha - \bar{y})^2$

We refer the reader to Davies or to the original work of Wilson and Box for a discussion of the actual calculation of the changes to be made in the independent variable to most rapidly increase the response.

The Canonical Form of the Second Degree Equation

It is possible and instructive to reduce polynomials like (17) to what is called canonical form. This can be done in two stages. Terms linear in the variables are removed by a translation in the u_1, u_2, u_3 space while bi-linear terms may be removed through an orthogonal rotation of axes in that space. It is usually easier to visualize the nature of a response surface when expressed in canonical form.

The linear terms in (17) are removed by writing $u_i' = u_i - u_{iM}$, $i = 1, 2, 3$ and $\eta' = \eta - \eta_M$ where u_{iM} is the value of u_i obtained from the maximization equations (19) and η_M is the value of η obtained by substituting the u_{iM} in the right-hand side of (17). Then (17) reduces to

$$\begin{aligned} \eta' = \beta_7 u_1'^2 + \beta_8 u_2'^2 + \beta_9 u_3'^2 \\ + \beta_4 u_1' u_2' + \beta_5 u_1' u_3' + \beta_6 u_2' u_3'. \end{aligned} \tag{20}$$

The cross-product terms in (20) are eliminated and new coefficients obtained for new variables U_1, U_2, U_3 such that

$$\eta' = B_1 U_1^2 + B_2 U_2^2 + B_3 U_3^2, \tag{21}$$

by an orthogonal linear transformation,

$$\begin{aligned} U_1 &= a_{11}u_1' + a_{12}u_2' + a_{13}u_3' \\ U_2 &= a_{21}u_1' + a_{22}u_2' + a_{23}u_3' \\ U_3 &= a_{31}u_1' + a_{32}u_2' + a_{33}u_3'. \end{aligned} \tag{22}$$

Values of B_1, B_2, and B_3 are solutions of the determinantal equation in B,

$$\begin{vmatrix} \beta_7 - B & \beta_4/2 & \beta_5/2 \\ \beta_4/2 & \beta_8 - B & \beta_6/2 \\ \beta_5/2 & \beta_6/2 & \beta_9 - B \end{vmatrix} = 0, \tag{23}$$

which in this case is cubic in B and hence has three roots yielding the coefficients in (21). The coefficients in (22) depend on the elements of (23) with B_1, B_2, B_3 substituted in turn for B. For example, to find a_{11}, a_{12}, a_{13}, we must solve the equations

$$\begin{aligned} (\beta_7 - B_1)a_{11} + \beta_4 a_{12}/2 + \beta_5 a_{13}/2 &= 0 \\ \beta_4 a_{11}/2 + (\beta_8 - B_1)a_{12} + \beta_6 a_{13}/2 &= 0 \\ \beta_5 a_{11}/2 + \beta_6 a_{12}/2 + (\beta_9 - B_1)a_{13} &= 0. \end{aligned} \tag{24}$$

This is desirable in that it is necessary to be able to transform from one set of variables or coordinates to another. Equation (22) essentially determines the principal axes of the conic given by (20).

Summary

We have attempted to at least indicate the statistical and mathematical techniques underlying the study of response surfaces and optimum operating conditions. Our comments are necessarily brief. More details on much of this work may be obtained from Davies. A good reference on multiple regression is Anderson and Bancroft[2]. Some of the basic references on the fitting of response surfaces are given on page 20.

References

(1) O. L. Davies, *Design and Analysis of Industrial Experiments*, Oliver and Boyd (Hafner), 1954, Chapter 11

(2) R. L. Anderson and T. A. Bancroft, *Statistical Theory in Research*, McGraw-Hill, 1952, Chapter 14

(3) G. E. P. Box and K. B. Wilson, "On the Experimental Attainment of Optimum Conditions," *Jour. Roy. Stat. Soc. (B)*, 1951, 1-45

(4) G. E. P. Box, "The Exploration and Exploitation of Response Surfaces—Some General Considerations and Examples," *Biometrics 10*, 1954, 16-60

(5) G. E. P. Box and J. S. Hunter, "A Confidence Region for the Solution of Simultaneous Equations with an Application to Experimental Design," *Biometrika 41*, 1954, 190-200

(6) R. M. DeBaun, "Block Effects in the Determination of Optimum Conditions," *Biometrics 12*, 1956, 20-22

BOOK REVIEWS

W. D. Baten, Editor

26 University Drive, East Lansing, Mich.

MODERN BUSINESS STATISTICS by J. E. Freund and F. J. Williams, published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey, price $7.50, pages vii-539. Reviewed by Theodor D. Sterling, Statistics Dept., Michigan State University.

The book frankly emphasizes descriptive materials and methods. The student is introduced at great length not only to the usual measures of central tendency and of dispersion but he also finds instruction on presenting and summarizing frequency data into charts and tables. The authors go so far as to devote one section (Appendix I) to "Pictorial Presentation" in which they show how to convert tabular data into rows of houses or human silhouettes, cut pie charts into components, or color statistical maps to represent frequencies. Comparatively little space is given to inductive or inferential methods although the authors attempt to familiarize the student with relatively advanced concepts such as factorial design or multiple regression.

The book can be divided into convenient sections. Chapters 1 to 5 deal with collations and descriptions of data in aggregates, graphic and tabular presentations, computation of most of the standard measures of relative location and variation. Procedures for grouped and ungrouped data are given in detail. In addition, Chapter 5 is devoted to the discussion of skewness and kurtosis.

Chapters 6 to 8 introduce the student to probability and theoretical distributions. Again considerable effort is spent on binomial, normal, and sampling distributions in an intuitively descriptive rather than the customarily mathematical manner. This section, despite its descriptive flavor, serves as the transition to problems of estimation, hypothesis testing, and sampling of Chapter 9 to 12. Regression and correlation are covered in two chapters, 13 and 14. The final four chapters of the book discuss at length index numbers and their uses, time series, and trends. Again descriptive aspects are stressed to the neglect of predictive or inferential uses of the latter methods.

The four appendices deal shortly with pictorial presentation, quality control, calculation with rounded numbers, and the use of logarithm and square root tables. Especially the latter appendix should prove very useful for the audience at which the book is directed.

The stated aim of the book is to correct the "poor balance between the more traditional topics of purely descriptive statistics and the newer topics of statistical inference (page vii)." It obviously succeeds in reestablishing descriptive topics—but in preponderance. For instance 34 pages are used to teach the essentials of the mean, mode, median and percentiles while only half this space (17 pages) is devoted to acquaint the student with the concept and usage of probability, only three pages are given to multiple correlation, and less than one page to simple factor analysis. Considerable space is occupied by computational methods using grouped data. It is open to question whether in our age of calculators and computors grouping methods are of sufficient importance to business and industry to warrant the thorough discussion given them by the authors. The descriptive aspects of the book would have been improved had the authors included some words about handling data by automatic means. Instead the student is asked to group and compute measures of location and variation for problems containing as many as 200 numbers. Such problems can be solved quicker and with smaller errors with a desk calculator by direct computation. After all, real large aggregates of data are seldom handled without IBM or similar equipment.

The inductive parts of the book suffer definitely from lack of adequate discussion. The authors, peculiarly, introduce relatively advanced topics while failing to devote space to preapodictic concepts. For instance, only four pages are used to present tests between two means for large as well as small samples. No mention is made of tests between means of matched groups or between groups that have unequal n's. It is, therefore, somewhat incongruous to find an introduction to factorial design a few pages later. Similarly, for use of χ^2 the test of independence is presented with no mention made of testing for expected frequencies and, in dealing with regression and correlation, the authors attempt such topics as multiple regressions and multiple and partial cor-

(Continued on page 28)

DESIGN AND ANALYSIS OF SCIENTIFIC EXPERIMENTS

A two-week special summer program for those involved in scientific experimentation will be offered by the Massachusetts Institute of Technology from Aug. 4-15.

The course will deal with the application of the laws of chance to the design and analysis of scientific experiments. The program will discuss in detail the central technique underlying a large part of modern experimental design—the analysis of variance. The emphasis will be on fundamentals leaving specialized topics for the student's later consideration.

The first week's lectures and laboratory will center on the probability and statistical theory underlying experimental design. The second week's lectures and laboratory will center on efficient experimental designs and their analyses. Lectures will be given by Prof. Harold Freeman with laboratory sessions under the supervision of Dr. Marian Krzyzaniak.

Tuition for the course is $250. Additional information may be obtained by writing to: Director of the Summer Session, Room 7-103, Massachusetts Institute of Technology, Cambridge 39, Mass.

Society Officers

Report of the Twelfth Annual Convention Boston Massachusetts May 26, 27, 28

Junior Past President Leon Bass (left) presents the gavel of office to newly elected President C. E. Fisher.

Open House

Old friendships were renewed and new ones established at an Open House, in the Georgian Room of the Hotel Statler, held by the Host Committee of the Boston Section for early registrants at the 12th Annual Convention. The Committee members were assisted by their wives in welcoming guests. The man who had traveled the furthest was quickly discovered at the coffee table. He was George W. Redding from the Australian Paper Manufacturers, Sydney, Australia.

Program

On Monday morning eight concurrent technical sessions started promptly at 10:30. The first listed was "Control Charts Without Calculation—Some Modifications and Some Extensions," by Paul C. Clifford, State Teachers College, New Jersey—moderated by Mason E. Wescott, Rutgers University. The 65th Session listed last on Wednesday afternoon was "Cost Reduction Through Control Gaging," by Louis O. Heinold, Federal Products Corp., Rhode Island—moderated by George Tamis, Champion Lamp Works, Lynn, Mass. The technical sessions ranged from "What the Department of Defense Expects of Contractors" to the latest mathematical techniques used in the analysis of complex problems in development and research.

Registration

In a year when budgets are tight and traveling expenses limited, 1450 registrants at the Convention were a sure sign that quality control is a very important cog in the workings of our companies from coast to coast.

Facilities

Two hotels were needed to provide room for exhibits, sessions, luncheons, and banquet. Headquarters and exhibits were at the Hotel Statler. Luncheons and the banquet were scheduled in the Ballroom of the Sheraton-Plaza. The hotels are a pleasant three blocks apart past Boston's handsome John Hancock Life Insurance Building and the famous Trinity Church.

Luncheons

On Monday, Warren Grosjean, the Host Chairman, introduced the feature speaker, The Honorable Perkins McGuire, Assistant Secretary of Defense. Mr. McGuire brought out the importance quality plays in the defense of our country. He pointed out that perfection is impossible, but whatever the nearest thing to perfection is, that's what we need in the weapons we are developing and producing today. He went on to outline the strengths of our armed services and the changes that have taken place in the type of equipment necessary to guarantee the security of our country, and at the same time emphasized the fact that what is true today is not necessarily true tomorrow. We must keep in the front position in the technological race—in which the quality engineers play a major role—or else we will have forfeited the future of ourselves and our families.

Seated at the head table were: Leslie S. Eichelberger, Clarence R. Burdick, Ellis R. Ott, Leon Bass, J. Y. McClure, Henry J. Becker, C. E. Fisher, Dale L. Lobsinger, and the Reverend E. L. Curry.

On Tuesday, Mr. Erwin D. Canham, well-known editor of the Christian Science Monitor and the Moderator of "Meet the Editors" on TV, was introduced by Warren Grosjean.

Mr. Canham, in a most stimulating address, brought out the fact that small and large companies today voluntarily share their ideas and discoveries, in contrast to the secrecy which prevailed years ago when a new method was jealously guarded. He then went on to present the balance sheet for peace—opposed are the need for a stable government in France and the dangers of the Soviet military power; on the other side of the ledger, we

(Continued on page 24)

Board of Directors

Society Officers

President
C. E. Fisher
Cent. Off. Quality Engineer
Bell Telephone Laboratories
New York, N. Y.

Vice President
Clarence R. Burdick
Manager, Quality Control
Houdaille Industries, Inc.
Detroit, Mich.

Vice President
A. V. Feigenbaum
Mgr., Mfg. Operations
and QC Service
General Electric Co.
New York, N. Y.

Vice President
J. Y. McClure
Manager, Quality Control
Convair—Division of
General Dynamics Corp.
Fort Worth, Texas

Vice President
Ellis R. Ott
Chairman, Dept. of Appl.
and Math. Statistics
University College
Rutgers University
New Brunswick, N. J.

Executive Secretary
Leslie S. Eichelberger
Asst. to Director of Quality
A. O. Smith Corp.
Milwaukee, Wis.

Treasurer
Allan M. Hull
Supervisor, Engr. Analysis
United Air Lines
San Francisco, Calif.

Junior Past President
Leon Bass
Manager, Quality Control
Jet Engine Department
General Electric Co.
Cincinnati, Ohio

Chairman, Editorial Board
Mason E. Wescott
Prof. of Appl. Stat.
University College
Rutgers University
New Brunswick, N. J.

Executive Directors

David C. Browne
Vice President
Sales & Promotion
The Broderick Company
Division of Harsco Corp.
Muncie, Ind.

Rocco L. Fiaschetti
Mgr., Film Quality Control
Ansco, Division of General
Aniline & Film Corp.
Binghamton, N. Y.

Gerald J. Lieberman
Assoc. Prof. of Stat.
and Ind. Engineering
Stanford University
Stanford, Calif.

August B. Mundel
Director, Quality Control
Sonotone Corp.
Elmsford, N. Y.

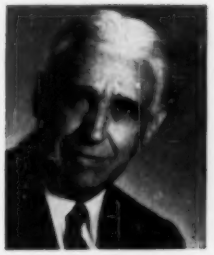
Warren R. Purcell
Manager, Quality Control
Missile Systems Division
Raytheon Mfg. Co.
Lowell, Mass.

Board of Directors

Stephen C. Bates
Field Engineer
Bell Telephone Laboratories
Cleveland, Ohio

H. Davis Birch
Supv., Quality Procedures
& Controls
Jet Engine Department
General Electric Co.
Evendale, Ohio

Allin P. Deacon
Deacon & Associates
Quality Control Consultants
Brantford, Ont.



R. Shaw Goldthwait
Director of Quality Control
Collyer Insulated Wire Co.
Pawtucket, R. I.

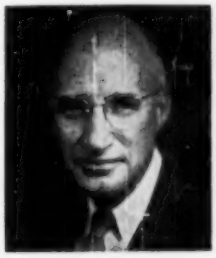
Sam L. Grasso
General Manager
Inland Automatic, Inc
Omaha, Nebr.

Robert H. Mayes
Quality Control Officer
Schenley Distillers, Inc.
Louisville, Ky.

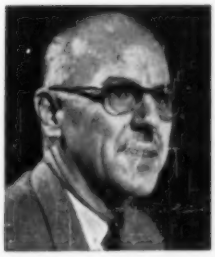
Gayle W. McElrath
Head, Ind. Engineering Div.
University of Minnesota
Minneapolis, Minn.

Paul S. Olmstead
Consultant in Engr. Stat.
Bell Telephone Laboratories
Whippany, N. J.

W. Ralph Reeves
Manager, Quality Coordination
and Development
Radio Corp. of America
Camden, N. J.



Harry G. Romig
Director, Quality Control
Paper-Mate Mfg. Co.
Culver City, Calif.



Irvin W. Schoeninger
Ass't Ch. Ceramic Engr.
Centralab Division
Globe-Union Inc.
Milwaukee, Wis.

Edward M. Schrock
Quality Control Engineer
American Radiator and
Standard Sanitary Corp.
New York, N. Y.

Richard B. Shartle
Stat. Cont. & Mkt. Res. Div.
Standard Register Co.
Dayton, Ohio

Stanley B. Sherwod
Quality Control Coordinator
General Motors Tech. Center
Detroit, Mich.

Charles T. Shewell
Research Specialist
Humble Oil & Refining Co.
Houston, Tex.

James T. Skelton
Chief Inspector
Caterpillar Tractor Co.
York, Pa.

Frank H. Squires
Director of Quality Control
Topp Manufacturing Co.
Div. of Topp Industries, Inc
Los Angeles, Calif.

Andrew P. Stergion
Manager, Quality Control
Corning Glass Works
Corning, N. Y.

Robert I. Tenney
Technical Director
The Fleischmann Malting Co.
Chicago, Ill.

Thomas E. Turner
Chief Inspector
Diamond Chain Co., Inc.
Indianapolis, Ind.

A special award was presented to the United States Department of Defense. President Bass is shown presenting the award to the Honorable Perkins McGuire, Assistant Secretary of Defense. Mr. McGuire was Monday's luncheon speaker.

(Continued from page 21)

find the retaliatory power we have, the dangers of dirty bombs, and the fact that war is becoming too dangerous.

Mr. Canham emphasized that we must present the essential values of democracy—the rights of man and freedom—to our friends abroad, not the luxuries of living in America.

At the conclusion, Mr. Grosjean presented a Polaroid Camera to Mr. Canham in appreciation of a talk which brought an ovation from his listeners.

At the head table were seated: John G. Rutherford, Edward M. Schrock, Herman Bogin, Reverend Joseph P. Donovan, William Youngclaus, Frank Caplan, Jr., and Wade R. Weaver.

Annual Meeting

At 4:45 pm Monday, the Annual Meeting of the Society produced the following results: President Bass announced the successful completion of the year's work; Executive Secretary Eichelberger described the Society's growth (102 active sections, 11,100 members) and improvements in office efficiency; Treasurer McClure presented the fiscal picture (balanced budget, slight surplus); and the Teller's Committee, headed by R. M. Hislop, reported the election of officers and the results of the balloting on constitutional amendments. The complete slate of officers proposed by the Nominating Committee were elected (see pages 22 and 23 for pictures of all the officers). All amendments were passed.

Social Evening

Monday evening conventioneers relaxed to dance music, refreshments, and a busy Monte Carlo directed by Bill Donovan of B. F. Goodrich Company. At the end of the Monte Carlo, winners with wads of paper money bid furiously at an auction of prizes donated as follows: two Telechron clocks, a pair of Stetson shoes, a National Radio, insulated rubber boots from B. F. Goodrich, two Vinyl rugs from Bird & Son, two Dennison Gift Wrapping assortments, a Polaroid Camera, a Keystone Movie Camera, a leather-bound dictionary from Houghton-Mifflin, and two leather suitcases from the Boston Section of ASQC. To top the evening off, a door prize of a bean pot, three cans of Boston baked beans and brown bread and that very essential tool, a can opener, were won by Dorian Shainin.

Exhibits

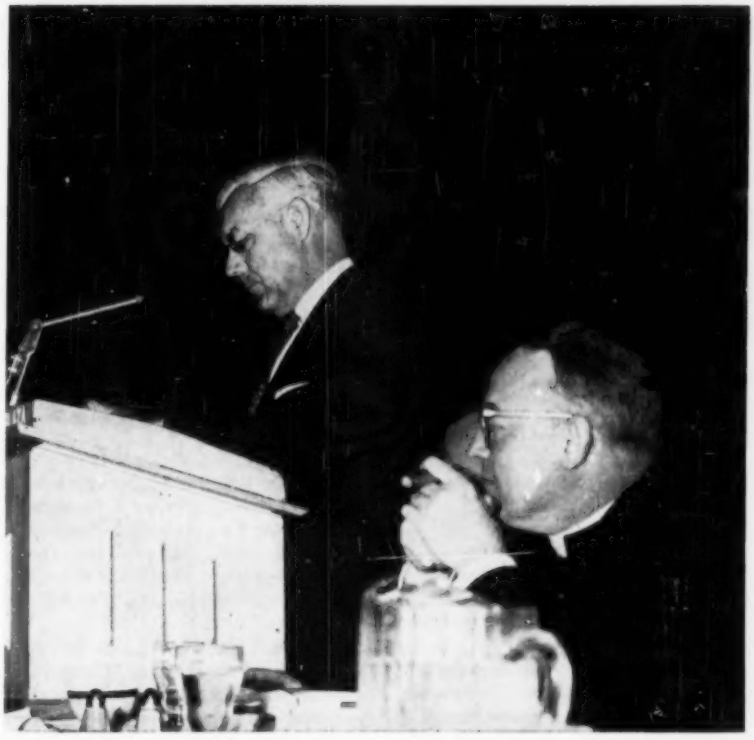
The exhibits, always an important part of the Convention, were arranged in the ballroom of the Hotel Statler with the Book Booth at the end. The following is a list of exhibitors.

Professor Charles R. Hicks accepts the Brumbaugh Award from President Bass for his outstanding paper "Fundamentals of Analysis of Variance."

Professor Edwin G. Olds introduces the 1957 Shewhart Medalist, Dr. Cecil C. Craig.

1958 Convention Exhibitors' List

1. Elliott Service Co., Inc.
   Mount Vernon, N. Y.
2. The L. S. Starrett Co.
   Athol, Mass.
3. M. E. Cunningham Co.
   Pittsburgh, Pa.
4. Friden Calculating Machine Co., Inc.
   Boston, Mass.
5. International Business Machines Corp.
   New York, N. Y.
6. Monroe Calculating Machine Co., Inc.
   Orange, N. J.
7. Keystone Camera Co.
   Boston, Mass.
8. Carl Zeiss, Inc.
   New York, N. Y.
9. Miles Reproducer Co.
   New York, N. Y.
10. Federal Products Corp.
    Providence, R. I.
11. B. C. Ames Co.
    Waltham, Mass.
12. American Cystoscope Makers, Inc.
    Pelham Manor, N. Y.
13. The Comtor Co.
    Waltham, Mass.
14. The Greist Mfg. Co.
    New Haven, Conn.
15. Wilson Mechanical Instrument Division, American Chain & Cable Co., Inc.
    Bridgeport, Conn.
16. Gillette Safety Razor Co.
    Boston, Mass.
17. National Electric Instrument Division, Englehard Industries, Inc.
    Elmhurst, N. Y.
18. Simonds Saw & Steel Co.
    Fitchburg, Mass.
19. Magnaflux Corp.
    Chicago, Ill.
20. Radio Corporation of America
    Camden, N. J.



Tuesday's luncheon speaker was the well-known editor of the *Christian Science Monitor*, Mr. Erwin D. Canham. Mr. Canham is also known as the moderator of TV's "Meet the Editors" program.

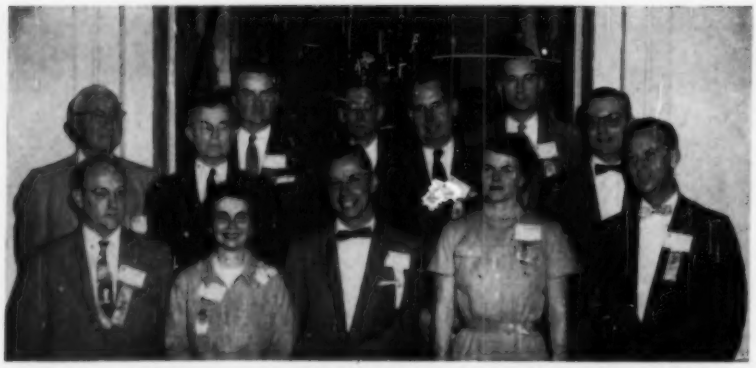
21. The Van Keuren Co.
    Watertown, Mass.
22. The Martin Co.
    Baltimore, Md.
23. TWA
    Boston, Mass.
24. Instrument Development Lab., Inc.
    Attleboro, Mass.
25. Waters Mfg. Co.
    Wayland, Mass.

Annual Banquet

The Annual Banquet started at 6:30 pm in the ballroom of the Hotel Sheraton-Plaza. After the National Anthem the Rev. Daniel Linehan, S.J.,

The 1957 Shewhart Medalist, Dr. Cecil C. Craig, accepts the Shewhart Medal and Official Citation from President Bass. (Dr. Craig's address appears on page 5.)

Junior Past President Bass accepts a gift of luggage from Retiring Junior Past President Dale Lobsinger. The officers and board of directors who served with Mr. Bass presented the gift in recognition of the many hours of hard work put in by Mr. Bass in directing the operations of the Society during 1957-58.



This is the group that deserves more than three-sigmas of the credit for the wonderful 12th Annual Convention—The Boston Host Group. Shown left to right are: (front row) Harold Davis, Dorothea Looney, Warren Grosjean, Frances E. Hermann, Martin Rogers; (back row) Charles Hudson, Harry Duane, William Donovan, Forest G. Fales, Arthur Costello, George Trumbour, Leonard Seder. Bernard Goldsmith was absent.

of Weston Observatory, delivered the invocation.

President Leon Bass introduced the members at the head table—Ralph D. Humphries, Cessna Aircraft Company; Harry G. Romig, Paper-Mate Manufacturing Company; Simon Collier, Johns-Manville Corporation; Wade R. Weaver, Republic Steel Corporation; George D. Edwards, Bell Telephone Laboratories, Incorporated (retired); Ralph E. Wareham, Consultant; Edwin G. Olds, Carnegie Institute of Technology; L. S. Eichelberger, A. O. Smith Corporation; J. Y. McClure, Convair Division of General Dynamics Corporation; Henry J. Becker, American Steel & Wire Division of U. S. Steel Corporation; Clarence R. Burdick, Houdaille Industries, Incorporated; C. E. Fisher, Bell Telephone Laboratories, Incorporated; Ellis R. Ott, Rutgers University; Dale L. Lobsinger, United Air Lines; Cecil C. Craig, University of Michigan; Mason E. Wescott, Rutgers University; Charles R. Hicks, Purdue University; Alfred L. Davis, Rochester Institute of Technology; Paul A. Robert, Precision Products Company of Cincinnati; Arthur Bender, Jr., Delco-Remy Division of General Motors Corporation; August B. Mundel, Sonotone Corporation; and Rocco L. Fiaschetti, Ansco Division of General Aniline & Film Corporation.

Leon Bass reviewed the past year, and read his article "A Letter from the President" from the September 1957 issue of *Industrial Quality Control*. He brought out that the management program was advancing in good style, and that the Society has over 11,000 members in spite of the recession. The Society is endeavoring to raise the professional qualifications and status of members so that it can further improve its recognition as a professional society. The division membership has grown to approximately 2700, and the Education Programs by sections is flourishing.

Mr. Bass then said that because of the cooperative effort of all the officers this past year we are still in the black and he wanted to thank them all for their help.

Mr. Bass then presented the Saddoris Award for Section Management to the Binghamton Section for their achievement in winning the contest.

The Brumbaugh Award was presented to Charles R. Hicks for the most outstanding paper published in Volume XIII (July 1956-June 1957) of *Industrial Quality Control*. Prof. Hicks' article, "Fundamentals of Analysis of Variance," was presented in three parts and appeared in the August, September, and October issues. It was subsequently reproduced in its entirety in reprint form. Prof. Hicks is assistant professor of mathematics at Purdue University and is also a member of the editorial board of *Industrial Quality Control*.

At this point Prof. Edwin G. Olds of Carnegie Institute of Technology made the following introductory remarks in introducing Dr. Cecil C. Craig, the winner of the Shewhart Medal:

Sponsor's Remarks on the Award of the Shewhart Medal to Professor Cecil C. Craig

Over the years, it has been remarkable that so many of the Shewhart Medalists have been men of distinction outside of the quality control field as well as within it. The man whom I present for honor tonight is no exception. In view of his eminence in other areas it is a tribute to the importance of statistical quality control that it has won so much of his time and energy.

Long before the American Society for Quality Control was organized, Dr. Cecil Calvert Craig had established his reputation as a mathematical statistician of the first rank. Soon after the Institute of Mathematical Statistics was organized at Ann Arbor in 1935 Cecil Craig was elected a Fellow. He was Vice-President of the Institute in 1939 and 1940. During the difficult war years of 1942 and 1943, he served as President.

From *Who's Who in America*, it is interesting to learn that Cecil received his A. B. and A. M. degrees from Indiana University, and his Ph.D. from the University of Michigan. For a year he was an American-Scandinavian Foundation Fellow at Lund University; for two years he was a National Research Council Fellow; and, for a year, held a Rockefeller Foundation Fellowship. He is a member of Phi Beta Kappa and of Sigma Xi.

Since 1922 Cecil Craig has helped to guide the development of theoretical and applied statistics at the University of Michigan. At present he holds, with distinction, the dual appointment as Professor of Mathematics and Director of the Statistical Research Laboratory at that institution. He earned his position by his

The responsibility of directing the Society's operations during 1958-59 will rest with these officers and executive directors. Left to right they are: (front row) Allan M. Hull, Leon Bass, C. E. Fisher, Ellis R. Ott; (second row) Rocco L. Fiaschetti, Leslie S. Eichelberger, Clarence R. Burdick, August B. Mundel; (back row) A. V. Feigenbaum, J. Y. McClure, Gerald J. Lieberman. D. G. Browne was absent.

scholarly achievements as a teacher of graduate students and as a research worker in his chosen field. Men whom he guided to doctorates are rewarding his efforts by their success in governmental, industrial, and educational posts. Of comparable influence have been his many research papers which have received publication in scientific journals of international distribution.

In view of these different responsibilities which he has, and these other opportunities for signal contributions, we of the American Society for Quality Control owe Cecil Craig a very special debt of gratitude for his services to our organization. Most of you know that Cecil was one of the original members of the Editorial Board of *Industrial Quality Control*. Many of you know of his work as director of the intensive courses which have been given at the University of Michigan each August since 1948. Many of you have profited from his teaching there and at Purdue.

Some of you are aware of his labors with our committees; Applied Methodology, Examining, Education and Training, General Technical Council, and others. You know about his help with convention programs. You have read his papers in *Industrial Quality Control*. The members of the Michigan Section, at least, know of the encouragement and guidance he gives to the activities in Michigan. That is why the section has elected him to honorary life membership.

It may be possible that only a few of you share my knowledge of Cecil Craig's early contributions to statistical quality control, back in the days when skepticism of its value was an almost universal characteristic. The Society of Industrial Quality Statisticians, a Pittsburgh fore-runner of ASQC, had Cecil Craig as one of its first speakers. It was Cecil who, in the early forties, made the trip from Ann Arbor to Detroit each week in order to teach a course in statistics for men in industry. When the Office of Production Research and Development decided to sponsor an intensive course at Carnegie in November of 1943, Cecil was drafted as a teacher. Then, before year-end, he gave his aid in Chicago and at the intensive course he helped to set up in Detroit. From then on, his services were sought for many of the other intensive courses given during the war period. These were among the courses which laid the foundations for ASQC.

Cecil Craig must find the work in statistical quality control stimulating and intellectually rewarding. Otherwise he would not be giving so much of his time to it. To me and, I believe, to you it is inspiring that a man of his stature should so direct his activities. His example should spur us to our work. Like Cecil, we must believe in statistical quality control. We must be firmly convinced that the world will be a better world because of our efforts.

President Bass, Officers and Members of ASQC, guests; I have the honor and the great satisfaction to present, as the Shewhart Medalist for 1957, the choice of the Shewhart Medal Committee, a man to whom we all owe a very large debt of gratitude—CECIL CALVERT CRAIG.

Prof. Craig delivered an address which was at the same time highly pertinent and humorous. The full text of Dr. Craig's talk is presented on pages 5-7.

After Dr. Craig's address the new officers were introduced and Mr. Bass turned over the gavel to Mr. C. E. Fisher, the new President, who asked the sections to work closely with headquarters and then pledged to the best of his ability to make the Society better, and to enhance the professional standards of the Society.

Then Dale Lobsinger, the Jr. Past President, presented a gift of two pieces of luggage to Leon Bass in appreciation of the fine leadership he has given the Society this past year, after which the meeting was closed by the new President, C. E. Fisher.

At the final luncheon on Wednesday Mr. H. Russell Beatty, President of Wentworth Institute, received, on behalf of the student branch, a plaque from Leon Bass which was the charter for the new student branch—after which Warren Grosjean closed the meeting. Eight technical sessions were presented from 2:30-3:30 and the 1958 convention became history.

RUTGERS ADVANCED CONFERENCE

A six-day advanced conference series on "Applied Statistics and Statistical Quality Control" will be offered Sept. 3-10. This advanced course is designed to provide additional instruction for persons who have had both a basic course and industrial experience in the SQC field.

It will include advanced topics in SQC such as sampling by variables, tests of significance, narrow limit gages in process control, sampling in chemical processes, practical designs of experiments, "trouble-shooting" in production, correlation and regression, management aspects of a quality control program. Familiar techniques will be extended and new ones presented to provide an integrated approach to industrial problems. Individual industry interests are served by providing laboratory sections grouped by area-interest; especially chemical, electrical, mechanical and advanced statistical techniques.

The full-time Rutgers staff members who will be associated with this advanced conference are: Professors Ellis R. Ott, Harold F. Dodge, and Mason E. Wescott. Special lecturers will include: J. Stuart Hunter, Enoch B. Ferrell, Allen R. Crawford, Richard S. Bingham, Jr., A. B. Mundel, Paul S. Olmstead, and David S. Chambers.

Tuition is $150 which includes text and instructional material. For additional information, write to Professor Ellis R. Ott, or Professor Mason E. Wescott, Rutgers University, New Brunswick, N. J.

Summer Statistical Methods in Industry Course

The third annual "Statistical Methods in Industry Course" will be held on the University of California, Los Angeles Campus during Aug. 11-22. This is a full-time program, sponsored by the Department of Engineering, University of California at Los Angeles, in cooperation with the University Extension and the Los Angeles section of the American Society for Quality Control.

To be offered are the following:

(1) A basic course in quality control by statistical methods.

(2) An advanced course in industrial statistical methods.

(3) A series of general lectures for all participants on such subjects as reliability in industry, statistics in research, quality control procedures, organizations, and reports.

(4) A "practical aids" series for all participants including computing and gaging techniques and instruments, and pertinent films.

Included in the staff will be Professor Irving Burr of Purdue University and Professor Lloyd Knowler of the State University of Iowa, and other distinguished representatives of government, education and industry.

The $250 fee includes tuition, books, supplies, ten luncheons and one dinner.

In addition to the above program, a three week course in industrial reliability will be held during Aug. 4-22. Because of previous reservations, only a limited number of registrations can be accepted for this course. Registrants should possess a degree in engineering or science or the equivalent. Fee for the industrial reliability course is $350.

For further information write Professor Edward P. Coleman, Coordinator, Statistical Methods in Industry Course, Department of Engineering, University of California, Los Angeles 24, Calif.

BOOK REVIEWS . . . continued from page 20.
relations without adequate discussion of the simple regression model. Other shortcomings in the section of correlation include the failure to mention the r to z transformation and the introduction of the Contingency Coefficient instead of Φ (for which the distribution is known and which students could handle since they had acquired facility in the use of the χ^2 table at a previous point.)

The discussion of trends, largely descriptive, could just as well have been placed at the beginning of the book with the rest of the descriptive materials.

Substantively, the book lends itself admirably for a low level first and terminal course in statistics if the material on inference is either completely deleted or complemented extensively by lectures or other readings. For such a course the authors' approach is ideal, especially since they have been eminently successful in keying ". . . to the lowest possible level of mathematical rigour at which it is felt that modern statistics can effectively be taught (page vii) . . ." Since it is unfortunately true that students having to take a single terminal course in business statistics are often low on motivation and background this book should offer a satisfactory base for any course that seeks to establish minimum comprehension combined with maximum practical usefulness.

SUPERVISOR'S CIRCLE

PAUL A. ROBERT, *Editor*

Precision Products Co. of Cincinnati, Box 130, Norwood 12, Ohio

Quality Control Do-It-Yourself Kit

E. R. CONOLLY

Rich Manufacturing Corporation, Battle Creek, Mich.

We, in quality control, are future-sighted, often losing sight of that day long ago when we first experienced the frustrations of trying to install a quality control department. With very few exceptions, we had department heads, management heads, superintendents, and personnel working under us who were afraid of the ideas that we were trying to get across. It was a rough, tough battle that we waged against ignorance.

It is to the new man in the field that these remarks are addressed; the old man doesn't need them. In the opinion of the writer, the older quality control man, who is probably in the manager class now, had a definite advantage. Most came into being during the war years when quality control had its greatest push as a means of getting war goods that were of a uniform standard of acceptance. Many firms, in order to qualify for contracts, had to have an inspection system that either duplicated the Government's acceptance system or was approved by the Government inspector. This, of course, meant a sampling procedure, or an inspection system that could show in black and white the steps taken to control the product from raw material to finished piece. All this helped us by more or less forcing top management to accept quality control, at least long enough to see the advantages of keeping it on the payroll.

Today, those in the aircraft and missile supply programs are much in the same position. The degree of reliability demanded is so high that control of the manufacturing processes for fabricating the product must be maintained. There is no way of assuring this degree of control better than modern quality control.

To many, however, the picture is not so rosy. Top management, caught between higher manufacturing costs and lower margins of profit, has read about the great things quality control can do for them. Pressure is put on some one individual, usually the chief inspector, to do something about the rising costs of manufacturing. This man has cast about for a solution. Finally "Eureka," there it is—Quality Control. Just look at the amazing things it can and has done. Saved this plant thousands of dollars; lower costs with tremendous increase in production in that plant, etc. All these glowing reports of achievement, yes, they are true, but like any dream they are the result of a lot of dreary work, sleepless nights, heartaches, and headaches on the part of some ONE or TWO men in the organization way back when the program was started.

The organization and installation of a quality control department in a plant that has had the old hit-and-miss type of roving inspection, plus a finish inspection department that sorts the good from the bad after all machining operations, presents many problems. A shop,

Editor's Comments

The article emphasizes the need for the tactful approach in introducing quality control, and the importance of being helpful to the production organization in achieving the common goal of better quality at lower cost.

For the new man in quality control, the association with others in the field is most important to sustain his enthusiasm and conviction in the validity of SQC's fundamental concepts.

regardless of how modern it may be, how well it carries on public relations, how well it carries out human relations, or how close the people feel toward management, is and always will be a tightly knit social group. They carry the weight of a social order. They look upon any ideas you wish to install in that order with hostility. This hostility is not against you as an individual, but against the enemies of the order—FEAR and CHANGE. These are the two principal obstacles to your success.

Fear: of redelegation of authority, reduction of prestige, disclosing information deemed sacred to an individual's need to the company; the unknown, (statistics are an unknown science to many people and are treated with awe,) subordinates knowing too much about the vital information as to costs, and many more fears may be found.

Change: people are most resistant toward change. In fact, they hate change of any kind. Any introduction of a new idea, such as quality control, disturbs the status of the society; such a disturbance must be repelled by any means at hand. One common means of eliminating the disturbance may be accepting quality control as such, but circumventing its authority by allowing supervisory people to by-pass the quality control department for decisions on quality matters.

There are as many ways to approach these problems as there are different manufacturing concerns. Each plant is an individual society with its own personalities and collective personality. There are some elemental steps that will aid the newcomer toward establishing a quality control department. These steps do not need to be taken in the order given; the approach must be tailored to the plant.

1. The one element that must exist, to make any program successful, is a firm belief that SQC can and will reduce costs, increase production, and pay for itself. This can be done, not only in the form of scrap reduction, rework control, and better production control, but in more indirect forms of savings in tools, increased machine use, lower inventories, and improved customer relations. The man responsible for installing quality control should attend a course in basic statistics as applied to quality control methods. This is essential, inasmuch as the man will have to be in a position to teach and train other people in the methods used.

2. In the establishment of a quality control department or program, care must be exercised that no attempt is made to force or cram the program down anyone's throat. There is no surer way to alienate any feeling of good will on the part of fellow management. An approach based instead on helpfulness by means of facts on present data will be appreciated.

3. Do not be in a hurry to put out a lot of charts in the shop. Charts are fine from your standpoint, but what good is a road map to a blind person? To the operators and foremen, they mean nothing, have no value. They show you up as a show off, a brain. They have no interest in your plots and will endeavor to get rid of them by befuddling the information. Charts should be used at the request of, or at least with the permission of the foreman. The foreman and the operator should know exactly what the charts are expected to show, how the measurements will be taken, and most of all that an explanation is given that they are for controlling the product, not the operator. This way of introducing the use of charts will tend to bring out help in the form of information that will enable you to make much more accurate decisions as to capability of the operation being checked.

4. Develop a program of information gathering that cannot be matched by any other department in the shop; this must be information pertinent to costs and timely so that corrective action can be taken promptly such as:
   (a) What tolerances are the various operations or processes capable of producing?
   (b) What operator, operations, or processes are responsible for the majority of scrap and reworking being produced?
   (c) What savings has the department head made by better training, supervision, and adjustment of machines?
   (d) What savings resulted by changes in tooling, improved methods, etc.?

   All these, and more, are the type of questions that you will be called upon to answer. The more useful your information, and the more departments that can use your information, the better able you will be to sell management on the development of a full scale quality control department.

5. Detail a complete outline for a quality control department, spell it out, time schedule for training, installing in different departments; people you will need, engineers, inspectors, pay schedules, in short the complete department, how much it will cost and the length of time it will take to install. Allow yourself plenty of time; it is awkward to explain additional time, but easy to take credit for doing a job in less time than planned. Someday, it will sink into top management's

For gaging close-tolerance holes

HERE'S PRECISION WITH ECONOMY

CHECK THESE FEATURES

- Large dial with .0001" graduations.
- Indicates actual size, a fixed—not passing—reading.
- Portable—no wire, hoses, stands or electronic gear.
- Positive 2-point gaging—automatic centering.
- Assured accuracy regardless of who operates it.
- Shallow holes, deep holes, inside splines, open-end holes gaged easily.
- Detects ovality, back or front taper, bell mouth, barrel shape.
- Reaches to bottom of blind holes.
- Will gage work in the machine.
- A shop tool for all-day every day use.

CHECK THESE USERS

Airesearch Mfg. Co.
Allison Div.
Apex Electrical Mfg.
Buick Motor Div.
Century Electric Co.
Chicago Pneu. Tool
Chrysler Corp.
Continental Motors
Curtiss-Wright
Detroit Transmission
Douglas Aircraft
Fairchild Engine & Airplane Co.
Falk Corp.
Ford Motor Co.
General Electric Co.
Hamilton Standard Division
Harris Seybold Co.
Homelite Corp.
Int. Harvester Co.
Jacobs Mfg. Co.
Lycoming-Spencer Div.
McDonnell Aircraft
National Lead
Northrop Aircraft
Pontiac Motor Div.
Scintilla Magneto
Steel Products Eng.
Studebaker-Packard
Sylvania (Atomic Div.)
United Airlines
Warner Gear Div.

SEND FOR BULLETIN 50 →

COMTOR COMPANY, 80 FARWELL ST., WALTHAM 54, MASS.

COMTORPLUG

head that quality control is what they need, and by golly, you had better be prepared to take advantage of it right now, or your chance will be gone with the wind.

6. Establish regular contact with the customers of the company through the quality control department. This is best done by letting the quality control manager visit the inspection department of the customer so that you will be informed of any changes they make in their inspection procedures. These visits also will help in customer relations by making them aware of your interest in their problems with your product. Let your customer know what corrective action you have taken to prevent a recurrence of defective shipments.

7. Build the quality control department along established lines of authority. That is, the lines of authority must be maintained in order that legality of decisions can be upheld. There can be nothing more sad than a quality control department responsible for quality, without authority to enforce certain rules for getting the desired quality. Not only decisions as to quality, but information on which such decisions are made must come from recognized sources of authority.

The frontiers of quality control and its applications are expanding at a great pace; new applications are being found every day. Join your local sections so that you can get help from your local men in quality control; they will be glad to help you get started. Good luck!

From the Scrap Box

MASON E. WESCOTT, *Editor*

University College, Rutgers University, New Brunswick, N. J.

Practical Application of Management by Exception

JULIAN H. TOULOUSE

Owens-Illinois Glass Company, Toledo, Ohio

The panel discussion on "Management by Exception" during the Second Annual Conference of the Administrative Applications Division in Cleveland on Feb. 7-8 was definitely a "planned experiment." Under the chairmanship of Dale Lobsinger, four panel members (Emil E. Ebner of Standard Oil of Ohio, Glenn D. Babbitt of Jack and Heinz, Inc., Charles C. Chopp of the Cleveland Electric Illuminating Company, and Fritz Kreidler of the Premier Autoware Company) each in turn proposed a problem. Five other panel members (Dr. Carl Noble, Harmon S. Bayer, Dr. Fred Leone, Dorian Shainin, and Dr. Julian H. Toulouse) took a fast look at the problem and suggested approaches to a solution. With ten minutes allotted for the question and with 20 minutes for the answer, this session took on some of the aspects of an electronic computer together with "the music goes round and round."

Mr. Chopp's problem concerned the follow-up and control of economic decisions for capital expenditures of items costing less than $5,000, some 1500 of them yearly, purchased by 700 supervisors on their own responsibility. Some purchases were found to be uneconomic or ill-advised. He gave the backgrounds, pointed out that many considerations affected the correctness of the decision to buy or not to buy, and asked what controls should be used, whether each capital expenditure should be reviewed, and if a sampling plan would be desirable for review.

Answers centered around the reasons for errors. One panelist thought that a start could be made by sampling past decisions for causes of error, with a belief that most would be in the area of economic savings. The 700 supervisors could not be called experts in this field and it was mentioned that one company passes all such purchases (under $5,000) through a department which studies the economic balance. This largely checks the problem of "forced" favorable data.

Another approach is to sample at random past purchases, and from the results maldistribution curves could be plotted to determine the few vital areas for corrective action. Typical curves could be by supervisors' names against dollar loss, or by reasons against dollar loss. If the data were first aligned in order of loss, and then cumulative data plotted as a curve, starting the cumulation with the low losses, a sharp change of direction of the curve would bracket a significant area, whereas little change in direction would rule out this particular correlation as an exposition of variation in cause-and-effect. Since the "average" supervisor makes only two such purchases a year, the maldistribution curve by supervisors would probably not be very revealing, but the curve by causes might be, or other maldistributions like kinds of equipment purchased might be sought.

In this, as in all the succeeding questions, the problems of training people arise. People are individuals, hence the use of "average" data is not always helpful. In this problem we should not blame the supervisor for an incorrect decision, but help him arrive at the decision. The figures for labor, overhead, length of item use, are all statistical, having both averages and standard deviations, and these should be part of the economic decision. Training courses would be valuable.

Mr. Babbitt then outlined a problem of shrinkage of product in multi-operation production lines. While questions of "cover-up" of scrap might be part of the consideration, paramount issues were that orders could not be under-filled, and under the incentive program labor was being paid for more parts than came out at the final operation. Insufficient quantity called for expensive jobbing of additional parts through the process with

delay in filling the order. Cost control and price estimate depended upon better knowledge of shrinkage. Losses amounted to $125,000 annually. An expensive method of counting at each work center along the process was now used. The question was: "Could a statistical checking plan adequately replace our present group of five full-time counters and numerous inspectors who also spend an average of 30 percent of their time counting?"

Panelists (except one) agreed that the basic problem has little to do with statistics, but a misunderstanding of the philosophy of building an organization. One must set out to train people to be correct, not set up an organization to disprove it, and to help, not police the people on the line.

Statistically, the 100 percent inspection (counting) is not good. Sampling can do a better job, particularly if some prior distinction is made as to the cost of error. Lost cost areas could be ignored in the general sampling study, and the cost of sampling and review confined to the most lucrative areas. First, however, a reliable method of collecting data is needed for the study of sampling.

If not now in use, a lot card should be set up to accompany each lot through the line. It should list the starting number, then the number *leaving* each department. Each department would note the scrap and reasons. At this point each department would be responsible for its own data. It would not be charged with reviewing the previous department's discrepancies.

Now begin sampling the cards. Major discrepancies between departments would show up where the sum of the scrap and the items leaving the department would not tally with the number leaving the previous department. These inter-department areas are the places where further work can be done on the accuracy of the count. When accuracy between departments was established, then a more reliable estimate of the units to *start* through the line would be possible. Scrap records, being more reliable, would serve as the start of a quality control program for correction.

The one dissenting panelist suggested the company should first remove the costly present counting many times of all material. If shrinkage does not return, all is well and there will be a real saving. If and when it does return, follow a random sample of lots from start to finish recording the shrinkage at each department. A relatively few locations, perhaps even one or two, will be found to account for most of the shrinkage. This objective information then leads to more permanent and less costly corrective action than the continuous counting, even if it were on a sampling basis. The only final control needed would be the initial and final count of each lot. If that ever shows shrinkage returning, another random sample of lots will identify the new causes for corrective attention.

Next in order came Mr. Kreidler with a problem in decision, particularly in the speculative field of planning the inventory of a new item of unproven sales potential, as an automotive replacement part. The business is such that this is a constantly and frequently occurring problem. Because time is of the essence, the competitive penalty of under-estimating the initial inventory can be great, and any over-stocking becomes a slow moving loss at the end of the market life of the item. Many are tied to new automotive models, and sales depend in part on the popularity of that model. The question imposed was "What types or techniques of analysis to direct plans of action are suggested to minimize risks associated with speculative inventories?"

There were about as many answers as there were panelists (or at least $N-1$ answers). Operations Research was mentioned more often than any other approach. It seemed to be agreed that whatever the answer, there still remained a large area of speculation.

Two fields were discussed: the forecast, and the correction of the forecast.

The simplest approach to the figure for total sales involves two probabilities and an estimation. First is the probability that the item will need to be replaced, second the probability that it will be purchased from Premier Autoware (or through his chain of supply) and an estimate of the total volume of the key item (such as certain car model) that will be produced. Even without further refinements (adding complexity and very likely more probabilities) there will be a maximum and a minimum answer depending on whether one takes a bear-ish or bull-ish estimate of the market. Probabilities can be estimated by statistically assigned experiments.

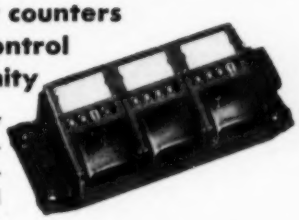
Based on composites by months, of previous items of the same general class, and including "hits" as well as "misses," one can make an "average" forecast of the monthly sales and the necessary monthly inventory and production as functions of the expected total sales. Original inventory should be based on as many months as would be needed for information on sales to return, plus production lead-time. Then an "all-time" production formula could be set up for controlling each month's production. A typical example, of how the formula might come out, would be:

Production for the month (or PM)
= 0.5 forecast for the month (m)
+ 0.25 forecast for next month (m+1)

VEEDER-ROOT

VARY-TALLY

gives you as many counters as you need for control of product-uniformity



Production figures by types of units . . . comparative test results . . . inventories, estimates, traffic and quality control checks . . . basic business data of *all* kinds is readily obtained with Vary-Tallies that are assembled to your exact needs. Spacious key on each counter makes "keyboard counting" easy, fast, accurate. For bulletin and prices, write:

VEEDER-ROOT INC.
HARTFORD 2, CONN.

"the Name that Counts"

+ 0.125 forecast for the 2nd following month (m+2)

+ 0.0625 forecast for the 3rd following month (m+3)

+ 0.5 (Planned inventory less actual inventory)

This minimizes the total variable costs, and allows (through inventory changes) for errors in the forecasts. Better forecasts will of course result in lower "minimum cost."

The last problem, presented by Mr. Ebner, was the control of equipment failures in a petroleum refinery. It chiefly concerned prevention of damage through replacement before failure, and it is therefore a replacement problem. Data were given which already showed a downward trend, in total failures, but a variable trend, by units, over a series of eight six-month periods.

The answer-panel concerned itself chiefly with two areas—correct maintenance records, and research or laboratory studies. The latter was the basis of almost every speaker's remarks, and became matters of designed experiment into corrosion problems and life testing. The theory of accidents was also mentioned as an approach, together with interaction wherein the initial failure of one part may cause failure of another part.

In order to guide laboratory experiments under accelerated conditions, as a method of evaluating the probability of failure against time of new materials or designs, one needs an estimate of the standard deviations. This cannot be done by allowing each part to run until failure (without coming up with a disappearing refinery unit now and then) but only by estimation from the data of the seventy-two failures the company has experienced during the past four years. From these estimates one would then plot the lower extreme tails of the distribution curve of number of failures against hours of operation. It is questionable both because we have no idea of the shape of the complete curve, nor do we know if maintenance and replacement had retired equipment which would have changed the tail area of the curve of failures. In a sense, the distribution curve is that of "wrong decisions" in maintenance, balanced by an opposing area of too early (economically) replacement.

With this estimate, good or bad, we can at least fix the point in time of operation for a given part of the system at which maintenance can give closest inspection, such as the present operations based on wall thickness determinations.

The method evaluation has already been successfully applied in aircraft maintenance where equipment failure must also be guarded against. The details may necessarily differ but the techniques of decision are similar.

Summing up the meeting, while it solved no problems immediately, it served to show that there was an approach, generally statistical and often in operations research, which could be used to attack any complex problem. This presentation has been brief and does not quote any speaker directly, but as a member of the panel. As a "designed experiment" it can be called a success.

section briefs

ALBUQUERQUE . . . Some 130 members, their wives and their guests attended the annual dinner meeting on May 12 at the Kirtland AFB Officers Club. Richard A. Bice, director of field test, Sandia Corp., and a member of the Albuquerque City Commission, was guest speaker for the evening. Mr. Bice, whose long and active civic career recently culminated in his being re-elected to the City Commission with the largest total number of votes of all the competing candidates, spoke on the role of the scientist in the community.

BALTIMORE . . . "Most Successful" was the verdict of the members and guests who attended the annual dinner meeting on May 13 at Wilson's Restaurant. Following a delightful refreshment and fellowship hour featuring delicious hors d'oeuvres, a sumptuous dinner proved to be more than most of the diners could encompass. The piece-de-resistance of the evening was an extremely fine practical talk by Leonard A. Seder on the subject "Organizing for quality improvement." The question period provided many worth while discussions and comments from the audience.

The following officers have been elected to head the section during 1958-59: chairman—E. M. Glocker, W. R. Grace and Co.; vice chairman—F. J. Cullen, National Plastics Corp.; secretary—R. G. Hutter, Proctor Electric Co.; treasurer—D. H. Taylor, Bendix-Friez Division.

BATTLE CREEK-KALAMAZOO . . . The annual ladies night program was held on May 2 at the American Legion Hall in Battle Creek. Charles Smith, associate professor of the English department at Western Michigan University was the after dinner speaker. His subject was "Out of the woods and into the trees."

At that time the new officers for the coming year were presented. They are: Wm. Schideler, chairman; George Church, vice chairman; Arthur Damon, secretary; and Robert Muir, treasurer. We are looking forward to a very successful year with our new officers and hope they do as well as the officers now retiring.

BINGHAMTON . . . A most informative talk on "Reliability as it applies to quality control" was given by Ralph E. Kuehn, manager of reliability engineering of IBM Corp., Owego, N. Y.

The new officers for the 1958-59 season were installed. They are: J. A. Jirauch, chairman; D. L. Moses, vice chairman; S. M. Rogge, secretary; and H. G. Salisbury, treasurer.

Quality engineering, as a career, was presented to students and parents as part of the Roberson Memorial Vocational Guidance Series. Speakers included the following: C. H. Rubin, General Electric Co.; D. L. Moses, IBM Corp.; T. Lemoncelli, Endicott Johnson Corp.; and R. Fiaschetti, Ansco Div., GAF. Moderator for the panel discussion was T. J. Mangan, IBM Corp.

BUZZARDS BAY . . . John W. W. Sullivan, metallurgical engineer, American Iron and Steel Institute, was guest speaker at the annual meeting held May 13. The subject of his illustrated talk was "Statistical methods in steel technology." He cited case histories to demonstrate the use of control chart techniques in the solution of problems of variability. A lively question period followed his presentation. Newly elected officers were installed by out-going chairman Kenneth E. Bennett. They include: Hans Picard, chairman; John Ruggles, vice chairman; Kenneth V. Chace and Edward S. Rudnick, program chairman; Mrs. Elizabeth Counsell, corresponding secretary; Mrs. Geraldine Habicht, treasurer; Walter Nicholds, recording secretary and education chairman; and Mrs. Mary Lindenberg, publicity chairman.

CINCINNATI . . . The Cincinnati and Hamilton-Middletown sections had a most enjoyable time at the annual dinner dance at the Greenhills Country Club on June 13. The cocktail hour started at 6:30 pm with dinner being served at 7. At 8:30 Dick Schumann and his orchestra provided the type of music that makes your feet want to move. The 1958-59 officers were installed prior to the dance.

SECTION CALENDAR (JULY 20—AUGUST 31)

SECTION	DATE	PLACE	TIME	SUBJECT	SPEAKER
Japan	Aug. 6	JUSE	5:30 pm	Panel discussion on SQC in small or middle scale industries	H. Karatsu, Japan Telegraph and Telephone Public Corp.
New Hampshire	Aug. 30	Highway Motel, Concord	7:00	Executive Committee Meeting	——
San Diego	Aug. 7-8	El Cortez Hotel	——	1958 Western QC Conference	——
South Bend-Mishawaka	Aug. 17	Committee of 100 Rooms, Sherland Bldg.	7:30	The Coming Year	Charles M. Makowsky, Bendix Products Div., Bendix Aviation Corp.
Tucson	Aug. 5	——	——	University of Arizona Military Projects	——

QUALITY CONTROL SHORT COURSE

A two-week short course in quality control is being offered by Washington University with the cooperation of the St. Louis section of ASQC on Sept. 8-19.

The course is intended for personnel desiring what is considered to be basic and introductory information in the area of SQC. It will cover the various aspects of control charts, process control procedures, principles of acceptance sampling, use of Dodge-Romig tables and MIL-STD-105A, starting and managing a quality control program, machine capability studies, and application of quality control to design.

The staff will be comprised of: Kenneth Barten, assistant professor of industrial engineering at Washington University; Arch R. Burgess, professor and head of the department of industrial engineering at Texas A & M; and Irving W. Burr, professor of mathematics at Purdue University.

Fee for the course is $450, with application deadline date set for Aug. 15. Further information may be obtained by writing to: Industrial Engineering Intensive Courses, University College, Washington University, St. Louis 5, Mo.

Electronics Division News

ELECTION OF NEW OFFICERS AND COUNCILLORS

The following officers and councillors have been elected to serve for the 1958-59 calendar year:

Officers

Chairman	H. A. Schumer	International Resistance Co.
Vice Chairman	G. H. Beckhart	Radio Corp. of America
Secretary	H. D. Voegtlen	Radio Corp. of America
Treasurer	J. Bemesderfer	General Electric Co.

Councillors

District 1	B. P. Goldsmith	Raytheon
District 2	C. W. Wetzel	International Business Machines
District 3	G. R. Scheel	Sonotone
District 4	J. B. Pringle	Bell Telephone Co. of Canada
District 5	R. M. Jacobs	Radio Corp. of America
District 6	J. F. Teunisson	CAA Maintenance Operations Div.
District 7	E. H. Schuttenberg	Electric Printing Co.
District 8	L. Franco	Gruen Industries
District 9	R. Fitzgibbons	Bendix
District 11	R. Haertel	Warwick Corp.
District 12	R. Carlson	Napco Industries, Inc.
District 13	W. W. Greiner	Boeing Airplane Co.
District 14	T. E. Smith	Texas Instruments
District 16	J. H. Yueh	Lockheed Missiles Div.

ACKNOWLEDGMENT

The entire Division wishes to express its appreciation to Irv Schoeninger, Junior Past Chairman, whose inspiration and leadership have contributed substantially to the growth of the Division during the past year.

ANNUAL MEETING

Twenty-seven members and guests of the Division attended the annual meeting held on Monday evening, May 26, during the 12th Annual ASQC Convention held in Boston. The membership of the Division now stands at 787. A report on the 4th National Symposium RQC, co-sponsored each year by the Electronics Division, indicates that we can expect a modest financial return when the books are officially closed. During this year 545 copies of the 4th Symposium Proceedings were mailed, free of charge, to members who were unable to attend the Symposium.

Other activities of the Division during the coming year will be the preparation of a handbook on reliability techniques and practices in electronic equipment production and field support. Plans are underway to jointly sponsor a short course on reliability with the assistance of the IRE-PGRQC.

At the May meeting certificates were presented to 52 graduates of the spring educational series.

Cincinnati was declared a Master Section in the Saddoris Award competition for 1957-58.

CLEVELAND . . . At the May meeting the election of the following officers was announced: chairman, Charles H. Joseph, Jr.; vice chairman, Jim T. Oesterling; secretary, Charles E. Wolf; and treasurer, Frank Eidenmiller. The meeting, a tour of the Case Tech. Computer Center, was excellently presented and well attended.

CORNING-ELMIRA . . . P. T. Clark, vice president of Corning Glass Works, headlined our "management night" program on May 11 with an interesting and appropriate talk entitled "Management looks at quality control." Our thanks to Mr. Clark, who on very short notice kindly accepted to substitute for our scheduled speaker Stu Beekman of General Electric, who unfortunately had to cancel his appearance at our meeting.

CUMBERLAND . . . Dr. W. S. Connor of the National Bureau of Standards Statistical Engineering Laboratory addressed the section at the Fort Cumberland Hotel on the first day of the merry, merry month. His topic was "Experiments with many variables."

On May 9, by popular demand, a special meeting was held at the La Vale Fire Hall for the purpose of devouring shrimp and beer. Bob Hunter, Ted Kight, Ray Madden, and Leonard Murphy are commendable for the success of the party.

AIRCRAFT and MISSILES DIVISION NEWS

The Aircraft Division held their annual meeting at Boston's historical "Ye Olde Union Oyster House" on May 26. Forty-nine members and guests enjoyed a very fine lobster dinner which was planned and arranged by Leonard Seder.

Annual reports by all officers and committee chairmen reflected a prosperous and eventful year. Membership climbed to 611 which was better than a 10 percent increase for 1958. Many members were very active throughout the year and contributed a great deal through their administrative and special project assignments.

Subsequent to the division meeting, the Society's Board of Directors approved the division's request to change its name to the "Aircraft and Missiles Division" to reflect the broader scope of division activities.

Activities Award Certificates were presented to nine charter members in recognition of a special project completed this past year.

Dorian Shainin, a founding member and first chairman of the Aircraft Technical Committee, promoted and stimulated interest for the first Aircraft Conference held in Dayton in 1954. He edited the Aircraft Supplement No. 1 in 1953. A certificate was presented to Mr. Shainin for his efforts as "Division Program Chairman—1958 Annual Convention."

J. Y. McClure, a founding member of the Aircraft Technical Committee, promoted and stimulated interest sufficient to create an Aircraft Division in 1955. He served as the first division chairman and created the division "Newsletter." A certificate was presented to Mr. McClure for his efforts on a joint ASQC and AIA project, "Practical Statistical Quality Control in the Air Frame Industry."

H. B. Epstein, a founding member and the second chairman of the division and vice chairman when the division was organized, has recently been appointed General Chairman of the 1959 Conference. Mr. Epstein was presented a certificate for his efforts on the joint project with ASQC and AIA on a survey report of "Quality Control's Role in Reliability."

H. Earle Moore, a charter member of the division and a past secretary of the division, has served as vice chairman during the past year as well as being chairman of the Quality Control Committee of AIA. A certificate was presented to Mr. Moore for his voluntary efforts in developing "Basic Principles for ASQC Aircraft Division Co-sponsorship of Conferences" and the "Aircraft Division Conference Portfolio."

Dory Hillman, a charter member of the division and the first chairman of the Editorial Committee, has been responsible for publishing the "Newsletter" on a bimonthly basis for the past two years and handling the review of special articles to be presented to *Industrial Quality Control*. A certificate was awarded to Mr. Hillman for serving as chairman of the Aircraft Division Editorial Board for 1956-1958.

Allan Hull, a charter member of the Division, was a speaker at the first division conference in Dayton and has been active in the promotion of the division in the western region. A certificate was awarded to Mr. Hull for his efforts as general chairman of the San Francisco Conference in 1957.

Walter Hurd, Jr., a charter member of the division and responsible for promotional activities throughout the San Francisco area for the Division was presented a certificate for serving as program chairman of the San Francisco Conference in 1957.

William Colello, a charter member of the division who did a great deal to promote the first division conference in Dayton, was presented a certificate for serving as membership chairman for the year 1957-1958.

Kenton Willhite, a chater member of the division and an active member toward the promotion of divisional activities of the western region and particularly the Los Angeles area, was presented a certificate for his efforts on the speakers roster for the year 1957-1958.

The election of the new officers for the coming year was announced by the Tellers Committee. They are: chairman—Paul Allen, Beech Aircraft Corp.; vice chairman—W. A. MacCrehan, Bendix Aviation Corp.; secretary—John Rutherford, Lear, Inc.; and treasurer—David Archibald, Convair—San Diego. The four officers were in attendance at the meeting.

The following councillors were reported as elected for their respective districts, and seven were in attendance at the meeting. The fact that this many officers and councillors were able to attend the annual meeting is in itself a noteworthy accomplishment. It reflects interest and enthusiasm in the activities of the division. The division, through the guidance of the fine selection of new officers, will show continued progress and development of stature within the Society.

District	Councillor		
1	E. W. Clapp	9	L. C. Whitcomb
2	O. J. Boehm	10	K. V. Holm
3	A. E. Hughes	11	John P. James
4	Harry D. Greiner	12	Mrs. V. G. Hildyard
5	D. S. Poole	13	F. E. Porter
7	J. T. Carriker	14	T. E. Hoffman
		16	R. W. Young

In behalf of the retiring officers and councillors, we wish the best of success to the new officers and councillors, and solicit the continued cooperation and enthusiasm of the division members. Our thanks to all members and other participants in the activities of the past year.

Here are the new officers for next year. Left to right they are: Dave Archibald (treasurer); John Rutherford (secretary); W. A. MacCrehan (vice chairman); and Paul Allen (chairman).

EVANSVILLE-OWENSBORO . . . The annual ladies night was held at the Hotel Soaper in Henderson, Ky. on May 20. Members and their guests enjoyed Smorgasbord.

The following new officers were installed for the 1958-59 fiscal year: chairman—Ed Shafer; vice chairman—Floyd Johnson; secretary—Ione Vanover; and treasurer—Louis Hammond.

HAMILTON . . . R. Vance Ward, president of the Montreal section, was our speaker for the final meeting held on May 8. Mr. Ward, drawing on his experience in the field of "statistical acceptance sampling and practical application," delivered a most interesting talk which was greatly appreciated by the members and guests.

HAMILTON-MIDDLETOWN . . . A panel of experienced leaders in production, inspection, and sales presented their views on the subject "What does quality control have for me?" Judging from the response and following discussion from the floor, the May meeting was termed very successful.

The officers-elect for the 1958-59 season were announced. They are: chairman—Robert B. Merrill; vice chairman—George Ross; secretary—Alan Crossley; and treasurer—Harold P. Gaw.

HARRISBURG . . . Our meeting of May 7 was held in York at the Grandview Country Club. Members were treated to a rather technical talk by Dr. Milton Sobel of the Bell Telephone Laboratories in Allentown. The subject was "Ranking and selection problems."

Our last meeting of the year was held at Gladco Lodge in Spring Grove on June 4. Truly a magnificent setting for an outdoor get-together, everyone enjoyed the festivities. Many types of recreational activities were provided and refreshments were served. Although we did not have a guest speaker, we did have installation of officers for the coming year. In addition, members with 100 percent attendance at section meetings were given ASQC membership label buttons. Various other donated prizes were given away as door prizes.

HARTFORD . . . Dorian Shainin, in his talk before a packed house, discussed the coming trend for controlling quality within industrial organizations. The emphasis will be on decentralization of the present quality engineering setup. The QC manager will act as an advisor to quality specialists assigned to departments within the organization such as, purchasing, research and development, engineering, inspection, and manufacturing. These quality specialists, either professional QC engineers or technicians, will report directly to their department managers or superintendents such as, the chief purchasing agent, director of engineering, etc. Management will then be able to classify the efficiency of these departments by having quality specialists assigned to them. Mr. Shainin re-emphasized the use of statistical tools such as, lot plot, multi-vary analysis, and pre-control as essential in establishing quality control of the product from design to delivery. Actual savings totaling thousands of dollars were realized after the establishment of this particular quality control organization in several job shops and other larger organizations. Through the media of slides, Mr. Shainin related the time factor with the proportionate savings realized after this proposed system was installed. The results were so impressive that Mr. Shainin has been pressing quality personnel to sell the idea to their respective managements.

HUNTSVILLE . . . J. J. Heger, of United States Steel Corp., spoke on "Steels for aircraft and missiles" at the May meeting. No meetings are planned for the summer months.

INDIANAPOLIS . . . George Blackburn, Eli Lilly & Co., who is publicity and public relations chairman for the section, made a TV appearance on May 16 giving the viewers the section's predictions, as calculated by John Waldner of Eli Lilly & Co., for the qualifying speeds for the annual 500 Mile Auto Classic.

	Prediction	Actual Running
Fastest Lap During Qualifications	148.8	146.508
Fastest Qualifying Average for 4 laps (10 miles)	146.4	145.974
Slowest Qualifying Average Making Race	141.4	142.253
Average Speed for 33 Fastest Cars	143.9	143.445
Slowest Lap of Any of 33 Qualifiers	129.0	141.287

The results of the election of officers are: president, John W. Waldner, Eli Lilly & Co.; vice president, H. Melvin Handerson, Western Electric Co.; treasurer, Robert D. McNeff, Diamond Chain Co.; and secretary, Robert W. Fallowes, RCA Victor.

JAPAN . . . On May 7 the section enjoyed a group discussion on "Testing for differences between methods of preparing fish by use of a discriminant function" by W. D. Baten, P. I. Tack, and Helen A. Baeder which appeared in the January 1958 issue of "Industrial Quality Control." S. Matsui of Asahi Denka Co. noticed that "testing for differences" like this could be accomplished more simply by means of the application of Sheffe's method.

H. Karatsu of the Japan Telegraph and Telephone Public Corp. will point out the application of SQC techniques to small or middle scale industries in Japan on Aug. 6. The panel discussion will be held at JUSE starting at 5:30 pm.

LANSDALE . . . Our group was fortunate indeed to have had as our guide when we toured the state penitentiary at Graterford Deputy Superintendent Alfred T. Rundle. Mr. Rundle knew all the answers and for over an hour our section was bombarding him with questions. The prison itself houses quite a concentration of manpower—in all a total of over 2000 prisoners. The main corridor from which the five cell blocks stem is easily the length of two football fields. It was interesting to note that Mr. Rundle said the most difficult prisoners were professional and educated persons—therefore our quality control group would be very poor guests!

LOUISVILLE . . . At the monthly meeting held on May 12 at General Electric Appliance, chairman Allen Greene had committee chairmen present a brief resume of section performance for the year. During the year the section showed an increase in growth of ten (10) members over the previous year. The section's educational program for the year was most successful with a total of 120 persons enrolling in and completing courses presented by the section.

The guest speaker of the evening, Al Davies of General Electric's receiver tube department in Owensboro, gave a very comprehensive talk on "Life test acceptance sampling." Light refreshments were served following the meeting.

METROPOLITAN . . . On May 13 the section held its final meeting of the current fiscal year in the National Cash Register Auditorium. The speaker was Robert Schin of the West-

Dale Lobsinger Honored

United Air Lines annually confers recognition in the form of a Transportation Services Award on one person deemed most deserving to receive it from among some 9600 operating people in the company's largest administrative department. The award names that individual judged to have made the most outstanding contribution to administrative progress.

This year's award was made to Dale L. Lobsinger, President of ASQC in 1956-57, for the work he has carried forward at United Air Lines in developing and disseminating a Quality Control type of philosophy that has come to be accepted as an integral part of management policy within the company. Included in this is the adaptation and installation of SQC methods to several within-company applications leading to improved analysis and control of clerical, cost, and supervisory functions. The award also recognized, for Dale, the extensive participation he has had in the Public Relations aspect of promoting an active interest and acceptance of SQC methods generally, both within UAL and throughout a broad geographic coverage of industry as a member and officer of ASQC.

In making the award, Senior Vice President of UAL, Mr. Don Magarrell, stated that Dale's activities in the quality control field had earned for him the unofficial title of Mr. Quality Control within the company.

ASQC takes pride in reporting this singular honor to one of its senior citizens, and extends heartiest congratulations for the well deserved recognition Dale has earned.

MILWAUKEE—James Barrabee (front left) of the International Harvester Company, newly-appointed chairman of the Milwaukee section, receives the gavel at a recent meeting at the Miller Brewing Company from his predecessor, William Golomski of Oscar Mayer & Company, Madison. Also shown are Larry Neuman (top left) of the Miller Brewing Company, vice-chairman, and Darrell Schroeder of the Centralab Division of Globe-Union, treasurer.

ern Electric Co., Allentown, Pa. Mr. Schin discussed the very important aspect of "Can quality control pay its own way?" The paper was so interesting and informative that many of those present had extremely favorable comments. In particular, Dr. Joseph M. Juran was prompted to rise and state that this was one of the best lectures he had heard in recent years. Mr. Schin showed us how the Western Electric Co. controls not only quality but evaluates the cost of these controls and the savings achieved thereby. A very fine system is in effect which enables management to evaluate the effectiveness of the quality control department. Many pointers were picked up by the group present.

MID-HUDSON . . . Thirty-seven members and guests were present for the annual meeting held May 6. The group heard annual reports by Secretary Casper J. Rose and treasurer Wm. M. Cranston. In addition, incoming chairman Frank J. Sindelar spoke of plans for 1958-59.

The main speaker at the meeting was Robert M. Hofstead, assistant director of statistics at Bristol Laboratories, Syracuse. His topic was "Application of statistics in pharmaceutical manufacture." The talk was very well received and was followed by a lively question and answer discussion session.

MILWAUKEE . . . Miller Inn was the scene of the annual business and social meeting held on May 5. A large turnout enjoyed the hospitality of the Miller Brewing Co. and saw movies of 1957 games played by the hometown Braves. The new officers were announced as follows: chairman—Jim Barrabee, International Harvester Co.; vice chairman—Larry Neuman, Miller Brewing Co.; secretary—Bill Don Levy, Froedtert Malt Co.; treasurer—Darrel Schroeder, Globe-Union Co.; director—Bill Golomski, Oscar Mayer and Co. Reports were given on the year's highlights including the successful 5th Industrial Clinic, the drive for senior members, and the appearance of Sir Ronald Fisher as a guest speaker.

MINNESOTA . . . The section concluded its business year May 13 in the "Dutch" Room at Hamms Brewery in St. Paul. The 50 people who attended were treated to committee reports, lunch, and liquid refreshments. Formal meetings will be resumed in September.

MONTREAL . . . On May 14 Kenneth G. Cook of Thomas & Betts Co., Inc. gave a very interesting talk on "Vendor-vendee problems in the metal industry."

The new officers for the 1958-59 season are: chairman—R. V. Ward, Canadian Industries, Ltd.; immediate past chairman—B. H. Lloyd, Price Waterhouse & Co.; vice chairman—E. C. Longhurst, RCA Victor; secretary—G. S. Williams, Northern Electric Co., Ltd.; treasurer—C. I. Taylor, Trans-Canada Airlines; education & training—Prof. R. Lessrad, Ecole Polytechnique; program—A. F. Schmidt, Northern Electric Co., Ltd.; arrangements—J. L. Gauthier, Sherwin-Williams of Canada, Ltd.; membership—W. A. Lewis, Imperial Tobacco Co. of Canada, Ltd.; publicity—S. L. Humphries, Aviation Electric, Ltd.

NEW HAMPSHIRE . . . On May 13 the section combined a tour of the Portsmouth Navy Yard with a fine talk by F. B. Olson of the Norton Co. Rear Admiral R. L. Moore, Jr., shipyard commander, personally welcomed the group of 45 individuals representing 15 different local industries and had arranged a fine tour of the Navy Yard facilities, especially its quality control functions. Dinner was served in the Rockingham Hotel prior to Mr. Olson's talk on "The control of quality in abrasive products."

Charles Hudson attended the second consecutive meeting of the section, this time as a guest. The previous time he was moderator of a panel discussion by members. Chairman Charles Tallman urged members and guests to take advantage of the national convention in May and the regional convention which is to be held in October.

OMAHA-LINCOLN . . . Twenty-one members and guests met May 9 at the Capitol Hotel for dinner and to hear guest speaker O. R. Weaver of the Phillips Petroleum Co., JATO Rocket Plant. Mr. Weaver spoke on "Using attributes for measurement of continuous variables in rocket industry."

PITTSBURGH . . . The May 20 dinner meeting consisted of a panel discussion called "Quality control on the PANel." The moderator of the lively discussion covering many phases of QC was William Martin, technical statistician, Koppers Co. The four members of the panel were: William Goepfert, chief of statistical analysis section of the Metals Div., ALCOA; Prof. Fred Kindig, department of industry, University of Pittsburgh; Joseph Manuele, director of headquarters quality control, Westinghouse Electric Corp.; and Duncan McCune, staff statistician, Jones & Laughlin Steel Corp.

At a recent executive meeting an advisory council was formed. It will be the responsibility of this advisory council to take care of the long term planning of the section. The council consists of four past presidents of the section—Dr. Phillips Whidden, ALCOA; Frank Norris, Wheeling Steel Corp.; Dr. Fred Kindig, University of Pittsburgh; and Paul Brucker, Crucible Steel Corp. Dr. Edwin Olds has been named honorary chairman.

PORTLAND . . . "Easy on the foam" was the often heard remark at the June meeting. The hosts for this meeting were the amiable Lucky Lager Brewers. This was the annual social meeting where the members brought their wives or friends and unwound for an evening of easy conversation. This was the last meeting of the summer and the coming year's schedule was announced. The past year's accomplishments, as well as the financial report, were reviewed.

RHODE ISLAND . . . Newly elected officers for the 1958-59 season are: chairman—Lester W. Balser; vice chairman—R. Shaw Goldthwait; secretary—Fred Kolling; treasurer—Raymond B. Fournier; membership—Frank Bliven; publicity—Joseph G. Kowalski; educational chairman—Albert J. LaGreca; and Saddoris Award—junior past chairman Cazemiro M. Antonio.

ROCHESTER . . . On May 5 the food and beverage sub-group toured the Great Western Wine Co. plant at Hammondsport. About 45 people took the tour which proved to be very interesting. Dinner at the Whitecap Restaurant on Keuka Lake followed. Robert Noyes of Great Western made the arrangements. At a short business meeting the following officers were elected for the coming year: chairman—Lewis Beem, Gerber Products Co.; vice chairman—Henry Hinz, Jr., R. T. French Co.; secretary—Charles Woodman, R. T. French Co. New officers of the technical sub-group are: chairman—Robert Malach, Eastman Kodak Co.; vice chairman—James Colton, Stromberg Carlson Co. New officers of the gaging and meas-

MONTREAL—These new officers of the Montreal section stood still long enough for this group picture to be taken during the section's annual dinner meeting. Left to right are: front row—J. L. Gauthier, W. A. Lewis, R. V. Ward, C. I. Taylor; back row—G. S. Williams, Prof. R. Lessrad, A. F. Schmidt.

urement sub-group are: chairman—John Coughlin, Wollensak Optical Co.; vice chairman—Francis DeSerio, Rochester Ordnance District.

SAN ANTONIO . . . Dr. A. C. Rosander, chief, sampling and estimating methods section of the Internal Revenue Service, presented a most interesting and informative address on the "Use of statistical quality control techniques for cost analysis and control" at our May 13 meeting. Dr. Rosander's paper was based on actual methods devised by him and his staff over a three year period which has proved most effective.

SAN DIEGO . . . Be an intellectual tourist this year. Come to the Western Regional Conference to be held in the fabulous El Cortez Hotel, high on a hilltop overlooking beautiful San Diego. Time your vacation to coincide with the conference dates—Aug. 7-8. The program will provide eminently qualified speakers for both technical and administrative sessions (simultaneously) and San Diego will provide fun in the sun to suit your tastes. See your section chairman for more details. Please make your reservations early.

SOUTH BEND-MISHAWAKA . . . The section held its first annual all-day technical session on May 2. Its success was the result of hard work by the committees and the complete cooperation of the press, the Committee of 100, the Pick-Oliver Hotel and the section's membership. Eleven industrial exhibits were shown on the mezzanine of the Pick-Oliver Hotel in South Bend. A tour of the Bendix Products Division preceded the opening of the exhibits at 11:00 am. About 300 visitors were present representing communities from Indiana, Kentucky, Illinois, Michigan and Canada. The luncheon hour, the afternoon and the dinner hour featured the very finest of speakers. The Mayor of South Bend, the Hon. Edward F. Voorde, spoke on "Quality Control and the Community" during the luncheon hour. The afternoon speakers were: P. B. Niland, Ford Motor Company; and W. A. MacCrehan Jr., Bendix Radio Division. The featured after-dinner speaker was Hugo Petersen, Bendix Aviation Corp.

"Principles and techniques in precision measurement" was the title of the hard-hitting talk by John A. Harrington, chief engineer of the Do-All Company, Des Plaines, Ill. The occasion was the final business meeting on May 15. The 1958-59 chairman elect, Charles Makowsky and his slate of officers were introduced and sworn in by outgoing chairman, Wayne Miller.

The Committee of 100 Rooms, Sherland Building, will be the site of the Aug. 17 meeting. The subject of the meeting, which starts at 7:30 pm, is "The coming year." Charles M. Makowsky will be the speaker.

SOUTH TEXAS . . . The section held the last regular monthly dinner meeting for the season on May 14. The speaker for the evening was Dr. A. C. Rosander, Internal Revenue Service, who spoke on "How we sample income tax returns." Dr. Rosander's observations and remarks on sampling principles were especially interesting.

The pre-meeting training session was conducted by J. H. Moyer, technical service director, Champion Paper and Fibre Co., Pasadena. His talk was on the subject "The meaning of the coefficient of the component of variances."

TOLEDO . . . The annual husband-and-wife picnic held at Devil's Lake was a great success as testified by the 50 persons in attendance. Delicious food, potent refreshments, excellent recreational facilities at the M & S Mfg. Company's cottage, super-sonic boat rides (compliments of Commodore Ray Crouse), and a perfect summer day provided the right combination for a good time. Many, many thanks go to chairman Beatrice M. Dorn for a job well-done.

Chairman David A. Hettel announces the following committee chairmen appointments for the 1958-59 season: program—Ward W. Wright; publicity—Theodore R. Meyer; membership—Mrs. Beatrice M. Dorn; Saddoris Award—Margaret Meyer; arrangements—John R. Meeker and Floyd Matchett; educational—Hilton C. Fetting and Margaret Tobin; constitution—Dr. Julian H. Toulouse and Fred J. Weber.

TORONTO . . . On May 7 the section enjoyed an informative and interesting talk on "Quick and dirty methods used in SQC" given by S. Prout, Canadian Controllers, Ltd.

The second part of the evening was used for a business meeting. Chairman M. J. (Mike) O'Callaghan of British American Oil Co., Ltd., summarized the highlights of the 1957-58 activities, after which he thanked all officers, especially the acting secretary Miss Joan J. Wheler of the same company, for their support. Mike related to the members that plans have been laid for a two-year extension course in QC at the University of Toronto.

1958 WESTERN QUALITY CONTROL CONFERENCE

The San Diego Section, ASQC, is the host section for the 1958 Western Regional Conference. The conference will be held in San Diego, Calif. on Aug. 7-8. Conference headquarters will be in the beautiful El Cortez Hotel overlooking San Diego and the Harbor of the Sun.

San Diego section members are working hard at planning and organizing the conference to make it an outstanding success.

The two day program of the conference is a dynamic program directed at the problems we face today—packed with workable ideas—ideas that you can take home and put to work.

Some of the highlights of the 1958 Western Quality Control Conference include the following.

Program

Two full days of technical sessions, carefully selected from all over the country, are tuned to our conference theme *"Quality Control at the Modern Pace."*

The speakers who will present the subjects for this conference are eminently qualified, both by virtue of their formal training and by their extensive and varied background of experience. This conference will be of interest to both individuals and firms concerned with quality of product and services in the present day world of industry.

Techniques of quality control and inspection, and how they relate to modern concepts of design and manufacturing methods of all types of products and services will be discussed. New presentations will be made on statistical controls and how they can be administered effectively. Organization and administration of the quality control function, to cope with the problems of the modern pace is the subject of other new and enlightening presentations. From beginning to end this is a program to remember—designed to enlighten and stimulate the thinking of men and women with vision—a program packed with "down to earth" solutions for your "up in the air" problems.

Exhibits

Many of the manufacturing firms in the western region have consented to display some of the products they produce. The very latest in new equipment designed to facilitate quality control will also be shown. These displays will be in the Don Room for your pleasure.

Luncheons

At both of our luncheons we have arranged to present the educational phase of the "Modern Pace." Dr. William C. Rust, President of California Western University, will speak on "Education in a Democracy" at the luncheon meeting Aug. 7.

Professor David S. Belcher, Professor of Industrial Psychology, San Diego State College, will speak at the Aug. 8 luncheon on "Quality Control without Conflict," a presentation relating *understanding of the problem to educational background and experience.*

San Diego Quality Control Day

The Honorable Charles C. Dail, Mayor of the City of San Diego, has proclaimed Thursday, Aug. 7, as *Quality Control Day in San Diego* in recognition of the accomplishment of the ASQC in furthering the production of quality goods and services for our local and national economy. As a fitting close to this first day of the conference, those attending the banquet will hear Mr. Bernard F. Coggan, Vice President and Manager of Convair-San Diego speak on "Quality in Speed, Spirit and Space."

For a copy of the program and registration information write to L. I. Medlock, Chairman Promotion Committee, P. O. Box 1486, Old San Diego Station, San Diego 10, Calif.

The new officers of the 1958-59 season were all chosen by acclamation: chairman—W. Foskett, Flight Refuelling Canada, Ltd.; vice chairman—R. T. La Rosa, Acme Carbon & Ribbon Co., Ltd.; secretary—J. Boardman, Honeywell Controls, Ltd.; treasurer—W. Pukalo, Inspection Services, Department of National Defense. R. Cardno and M. J. O'Callaghan were elected directors. G. F. Milne, G. F. Hughes, W. J. Martin, and S. Brodsky were elected committee chairmen.

TUCSON . . . Dave Hill, quality director of Hughes Aircraft Co., introduced the topic "Successful vendor relations" at the May meeting. The film "A life in your hands" followed his initial remarks to demonstrate the difficulties in obtaining parts and components which will pass severe environmental test conditions. Participants in a panel discussion of the subject were J. C. deVos, general purchasing agent at Hughes-Tucson, J. J. Tamsen of the quality manager's staff at Hughes-Culver City, and M. C. Loomer of the outside quality department at Hughes-Tucson. This was one of the best attended meetings of the season with some 75 members and guests including interested purchasing representatives.

UNIVERSITY OF WESTERN ONTARIO . . . An executive meeting was held May 15 at the home of the retiring chairman, Russ Glenfield, when the new executive for 1958-59 took over. The new officers are: chairman—J. E. Crossman, Raytheon Canada, Ltd.; vice chairman—L. S. Moshier, Dominion Electrohome; secretary—D. L. Griffett, Eston Automotive; treasurer—A. G. Glennie, Dominion Electrohome; directors—R. W. Glenfield, E. O. Boddy, G. A. White; committee chairmen—E. O. Boddy, R. W. Glenfield; and district 4 representative—J. B. Pringle. Plans for the coming year were discussed and an executive meeting scheduled to get the ball rolling on a busy fall season.

WINDSOR . . . Andy Miller introduced K. P. Mazurek who was the guest speaker at the May meeting. Mr. Mazurek, director of industrial engineering at Chrysler Corp., presented "The intra-relationship between quality control, industrial engineering, and management." The thought was put across that to produce an economical and a quality product, both industrial engineering and quality control must have similar technical specialists. Mr. Mazurek pointed out to the group that industrial and quality engineers have two basic responsibilities—to insist on a fair day's work and to build a quality product. To improve relationship of engineering and quality control personnel we must avail and sell our services to production supervision. A very active question period followed the talk and John Anderson thanked the speaker on behalf of the members and guests in attendance.

SIGNIFICANT DIFFERENCES

. . . Cincinnati—New officers who were recently installed are: Don Brandt, Schenley Distillers, chairman; R. Hauch, Tanner's Laboratory, University of Cincinati, vice chairman; W. Eilrich, General Electric Co., secretary; and Mrs. Ada Diehl, treasurer.

. . . Corning-Elmira—William Moran has been appointed manager of the Micro-Wave Section, Westinghouse, Horseheads.

Stuart Frankel has been named supervisor of quality control for the "A" factory plant of the Corning Glass Works.

. . . Hamilton-Middletown—The following men were promoted at the Champion Paper and Fiber Co. in Hamilton: DuWayne Carlson has been appointed to special assistant to manager of process control; Robert Thompson—promoted to special assistant to chief inspection; Donald Jenkins—promoted to general supervisor of technical service section; and Wilbur Keller—promoted to paper machine superintendent.

. . . Harrisburg—Newly elected officers are: chairman—Steve Combs, York Div., Borg-Warner Corporation; vice chairman—George Thomas, Radio Corporation of America; secretary—Betty J. Bell, Radio Corporation of America; treasurer—A. B. Brown, American Chain & Cable Co., Inc.

. . . Hartford—Albert E. Aubin has been named quality manager at Underwood Corp.

Robert Van Camp has been appointed quality control engineering supervisor at Underwood Corp.

. . . Huntsville—William Spink of the Chemstrand Corp. and former section secretary-treasurer has been assigned as project engineer for start-up of the new Chemstrand, Ltd. acrilan fiber plant, Coleraine, North Ireland. Mr. Spink has departed for Ireland.

. . . Mid-Hudson—Frank J. Sindelar, newly elected chairman, announced the following appointments: "Industrial Quality Control" correspondent and Saddoris Award—Harold Loper; membership chairman—Dwight Q. Bellinger; program chairman—Wallace C. Stone; and publicity chairman—Louis Boek.

. . . Milwaukee—Lawrence Linson, formerly QC manager with Joy Mfg. Co. in Franklin, Pa., has been appointed QC manager at Bucyrus-Erie Co., South Milwaukee.

The American Foundrymens Society will shortly announce a 5-day advanced industrial engineering course to be given at Marquette University in the fall. One day will be devoted to quality control by statistical methods and the session will be given by a member of the section.

. . . Pittsburgh—Frank Caplan has been transferred from the Cheswick plant of Westinghouse Electric Corp. to the Blairsville fuel products plant where he will be manager of quality control.

Erwin Taylor has left Westinghouse Electric Corp. and has taken a position as a quality assurance engineer with The Martin Co., Baltimore.

C. L. Pratt of the Koppers Co. has been promoted to manager of the quality control department of the tar products division.

Jim Alexander was named staff supervisor of quality control at the Youngstown plant of Westinghouse Electric Corp.

Edward A. Reynolds has been appointed manager of quality control by the A. M. Byers Co. Mr. Reynolds will be in charge of quality control and inspection at the Byers' plants in Ambridge and Pittsburgh.

. . . Toledo—Congratulations to John Meeker, LOF Glass Fibers Co., on his promotion from plant quality control manager to general quality control manager.

Congratulations go to Ron Davis on his marriage to Therese Grabmeier in St. John's Church on May 17. May everyday be as happy as your wedding day, Ron and Therese.

. . . Windsor—I. S. Reid has retired from the Ford Motor Company.

The night of the May 21 meeting, the section past chairmen received a token of remembrance. In order of chairmanship they are: Don Malott, Fred Kennedy, George Dowling, and Ross Gowlin.

What's New?

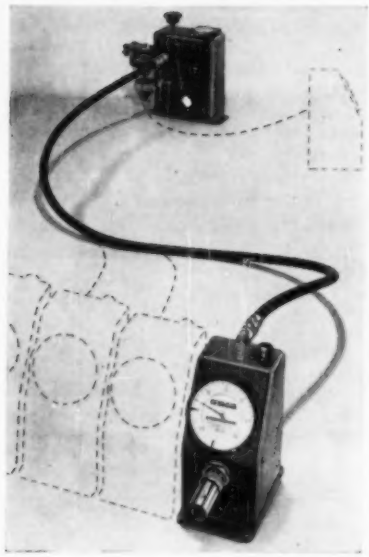
ROY A. WYLIE, *Editor*

When inquiring about "What's New?" items, please mention INDUSTRIAL QUALITY CONTROL

Mantec Inc., has developed a series of high-low temperature test chambers for use in combination with vibration test equipment. The chambers are compatible with the new high-force, hydraulically-powered Wyle Hydrashaker as well as with conventional electrodynamic vibrators. Clearance for the vibrator is provided by castered legs welded to a frame on which the chamber is mounted. An aperture is provided in the bottom of the chamber through which a suitable standoff can be mounted to the vibrator head. The test specimen is then mounted to the standoff, within the chamber. Access doors, instrumentation ports, etc., can be provided to suit customer requirements. Optional configurations are available to utilize block dry ice, liquid CO_2, or mechanical refrigeration for coolant. Electrical elements provide heating. Various sizes and performance ranges are available. Additional information is available from **Wyle Associates**, 128 Maryland Street, El Segundo, Calif., the engineering liaison agency serving Mantec, Inc.

★ ★ ★

Greater air gaging economy and flexibility has been made possible by the availability of the Federal Dimensionair Air Gage meter with remote pressure regulation and filtering. Since the Dimensionair incorporates a fixed magnification system, the filtering and regulating elements of the



gage are not called upon to perform the added function of setting gage magnification. This enables these elements to be separated physically from the metering portion of the gage, with one regulator-filter serving up to five meter units. Where numerous gaging operations are to be performed in a concentrated area, this arrangement saves valuable production space, because a meter unit (with its own zero adjustment valve and adaptor for air plug, ring, Air-Probe, or other sensing element) takes up much less room than the regular model Dimensionair with integral pressure regulator-filter. Meter units may be relocated easily since they are connected to the centrally located regulator by a five foot hose rather than by piping. Further information is available from **Federal Products Corp.**, 1144 Eddy Street, Providence, R. I.

★ ★ ★

clinics, conferences, and courses

JULY

. . . ***21-Aug. 1***—"Mathematical Analysis and Simulation in Industrial Operations" course, Massachusetts Institute of Technology, Cambridge, Mass., tuition $300, contact Herbert P. Galliher, program director, Operations Research Project, Massachusetts Institute of Technology, Cambridge 39, Mass.

. . . ***28-Aug. 1***—"Tolerance Management," Statistical Summer Seminar, MIT Endicott House, Dedham, Mass., contact Irving Weiss, Bell Telephone Laboratories, North Andover, Mass.

. . . ***28-Sept. 6***—Undergraduate and Research Seminars in Statistics, University of California, Berkeley, Calif., contact David Blackwell, Chairman of the Department of Statistics, University of California, Berkeley 4, Calif.

AUGUST

. . . ***4-8***—"Design of Industrial Experiments," Statistical Summer Seminar, MIT Endicott House, Dedham, Mass., contact Irving Weiss, Bell Telephone Laboratories, North Andover, Mass.

. . . ***4-15***—"Design and Analysis of Scientific Experiments," Massachusetts Institute of Technology, Cambridge, Mass., sponsored by MIT, contact Office of the Summer Session, Room 7-103, Massachusetts Institute of Technology, Cambridge 39, Mass.

. . . ***4-22***—Industrial Reliability Course, University of California at Los Angeles, contact Prof. Edward P. Coleman, Coordinator, Industrial Reliability Course, Department of Engineering, University of California, Los Angeles 24, Calif.

. . . ***7-8—"Quality Control at the Modern Pace," 1958 Western QC Conference, El Cortez Hotel, San Diego, Calif., sponsored by ASQC, contact 1958 Western Quality Control Conference, P. O. Box 1486, Old San Diego Station, San Diego 10, Calif.***

. . . ***11-22***—Statistical Methods in Industry Course, sponsored by the Department of Engineering of the University of California at Los Angeles and the Los Angeles section of ASQC, contact Prof. Edward P. Coleman, Coordinator, Statistical Methods in Industry Course, Department of Engineering, University of California, Los Angeles 24, Calif.

. . . ***18-28***—11th Annual Ten-Day Quality Control by Statistical Methods Course, University of Michigan, Ann Arbor, Mich., contact Prof. C. C. Craig, 106 Rackham Bldg., Ann Arbor, Mich.

(Continued on page 40)

Custom Scientific Instruments, Inc., Kearny, N. J. now offers the "Dow Gas Transmission Cell" to perform tests as specified in ASTM D-1434-56T "Tentative Method of Test for Gas Transmission Rate of Plastic Sheeting." This unit was developed by the Plastic Technical Service of the Dow Chemical Company. The redesigned cell will have the following advantages to aid the laboratory technician; the cell is calibrated for immediate use, all parts are removable for cleaning and replacement, and adapters are furnished for fast and slow gas transmission rates.

DO YOU HAVE A QUALITY CONTROL PRESENTATION PROBLEM?

QUALITY CONTROL AIDS ARE THE ANSWER

Make your presentation more forceful and understandable by the use of these aids.

QUINCUNX

. . . This device permits your audience to visualize the creation of a normal distribution pattern as well as the results of variables sampling. All beads are self-contained; nothing to drop out. Done in attractive mahagony complete with zipper carrying case.

ATTRIBUTE SAMPLING DEMONSTRATOR

. . Complete unit consists of transparent plastic container, opaque colored beads, and wood paddles permitting easy identification of beads at a distance.

SIMULTATORS

. . . To demonstrate control chart plotting and shift of distribution pattern.

Lightning Calculator Co.
Box 6192
St. Petersburg Beach 6, Fla.

Product Education Service

These advertisers provide educational information on their products, expanding the services of your journal, *Industrial Quality Control.*

Their support is twofold. First they place the latest information on product development at your finger tips. In addition their purchase of advertising space supports your Society and this publication. Continue to advance your Society by using their products and services and encourage others to do so. They all merit your consideration.

When writing or talking to advertisers to inquire about their products, always remember to say you saw their ad in *Industrial Quality Control.*

Advertisers in this issue

Bell Telephone Laboratories, Inc. 1
Comtor Co. 29
Eastman Kodak Co. . . . . IBC
Federal Products Corp. . . . . OBC
Lightning Calculator Co. 39
Sheffield Corp. . . . . IFC
Veeder-Root, Inc. 31

August . . . . continued from page 39

. . . ***29-Sept. 1***—Statistical Conference, University of St. Andrews, Edinburgh, Scotland, sponsored by Royal Statistical Society, contact St. Andrews Conference, Attn: Miss U Croker, Royal Statistical Society, 21 Bentinck Street, London, W 1, England.

SEPTEMBER

. . . ***8-19***—Quality Control Short Course, Washington University, St. Louis, Mo., sponsored by Washington University with cooperation of St. Louis section of ASQC, contact Industrial Engineering Intensive Courses, University College, Washington Universtiy, St. Louis 5, Mo.

. . . ***15-19***—13th Annual Instrument-Automation Conference and Exhibit, Philadelphia Convention Hall, Philadelphia, Pa., sponsored by ISA, contact Fred J. Tavery, Exhibit Manager, Instrument-Automation Conference and Exhibit, 3443 So. Hill St., Los Angeles, Calif.

. . . ***22-24***—7th Annual Meeting of the Standards Engineers Society, "Standardization — A Must for the Space Age," Benjamin Franklin Hotel, Philadelphia, Pa., sponsored by SES, contact F. F. Van Atta, 1916 Race St., Philadelphia 3, Pa.

. . . ***23-26***—Iron and Steel Exposition and Convention, Cleveland Auditorium, Cleveland, Ohio, sponsored by Association of Iron and Steel Engineers, contact Association of Iron and Steel Engineers, 1010 Empire Bldg., Pittsburgh 22, Pa.

OCTOBER

. . . ***13-15***—International Systems Meeting, Penn-Sheraton Hotel, Pittsburgh, Pa., registration fee $100, contact 1958 ISM, Parlor 70, Penn-Sheraton Hotel, Pittsburgh, Pa.

POSITIONS AVAILABLE

Address all replies to box number references to: American Society for Quality Control, Room 6197 Plankinton Bldg., 161 W. Wisconsin Ave., Milwaukee 3, Wis.

QUALITY CONTROL MANAGER

Leading manufacturer of Aircraft and Automotive heat exchange devices seeks qualified man for top quality control position. Must have specific experience in aircraft industry as quality control manager or assistant. Engineering degree desireable. Age 35 to 45. Compensation, including bonus consideration, comensurate with ability and experience. Please reply to Box 15N1 at the above address.

POSITIONS WANTED

Address all replies to box number references to: American Society for Quality Control, Room 6197 Plankinton Bldg., 161 W. Wisconsin Ave., Milwaukee 3, Wis.

MECHANICAL ENGINEER

Twenty-nine years' experience in design, research, production, quality control, cost reduction and sales phases in engineering of high production home appliances, electronics, and heavy machinery.

Strong background in metallurgy, manufacturing materials, processes and fabrication.

Desires creative design, liaison, sales or administrative engineering work. Prefers Connecticut location but will relocate. Please reply to Box 15A1 at the above address.

1958 Middle Atlantic Conference Transactions

The transactions of the 1958 Middle Atlantic Conference, sponsored by the Middle Atlantic Sections and the Technical Divisions of ASQC, are now available from the National Office in a paper bound volume.

Two-hundred-seventy-five pages of valuable technical knowledge and practical applications of quality control are ready to become part of your complete SQC library, NOW!

Thirty-two of the leading men in the quality control field teamed up to prepare the 30 papers that make up the conference transactions.

Here are the general topics the transactions cover.

- Administrative Applications
- Operations Research
- Armed Services and Government
- Management Use of QC
- QC in the Chemical, Metals, Automotive, and Textile Industries
- Control Charts
- Manufacturing Applications
- Planning and Programming
- Uses of Variables Data
- QC in the Assembly Line
- Problems and Solutions in Electronics
- Life Testing and Reliability

A limited number of the transactions are available but you can insure your receipt of a copy by MAILING THE ATTACHED COUPON TODAY!

AMERICAN SOCIETY FOR QUALITY CONTROL 7-58
161 W. Wisconsin Avenue
Milwaukee 3, Wisconsin

Please send me ..... copies of the 1958 Middle Atlantic Conference Transactions

@ $2.50 per copy. Amount enclosed .....

Name .....

Address .....

.....

(Make checks payable to American Society for Quality Control)

CONSULTING SERVICES

Responsibility of the American Society for Quality Control, Inc., for Consulting Services advertising is limited to certification that advertisers hold the grade of membership in the Society stated in their advertisements. Qualification requirements for the several grades of membership are set forth in the Constitution of the Society.

Management Controls
FOUNDED IN 1945
References and Literature on Request
Senior Partner: W. E. JONES, *Fellow, ASQC*
699 Rose Ave., DES PLAINES, ILL., *Vanderbilt* 4-6533

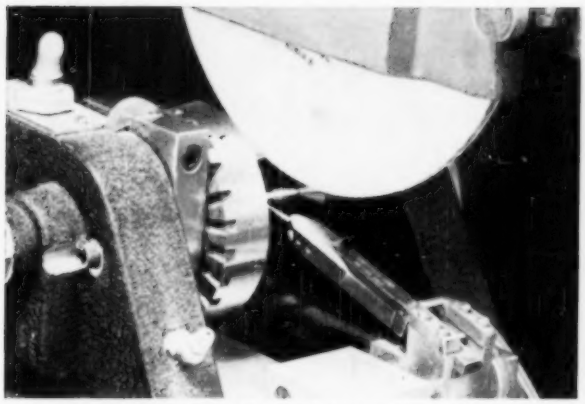
Consulting Services in Quality Control
RALPH E. WAREHAM
Fellow, ASQC
122 Orchard Ridge, Chappaqua, New York
Telephone Chappaqua 1-0715

Quality Control Consultant
HARMON S. BAYER
Fellow, ASQC
1154 Book Building, Detroit 26, Michigan
Telephone WOodward 5-3796

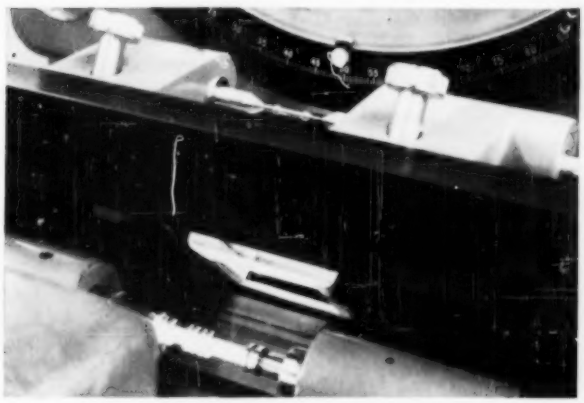
QC Planning — Defect Prevention
LEONARD A. SEDER
FELLOW ASQC
267 HAWTHORNE ST.
MALDEN, MASS.
MAlden 4-5446
Organizing for Quality — Training

BERNARD HECHT
Quality Control & Reliability Specialist
Senior Founding Member, ASQC
Planning and Staffing
Q. C. Organizations
Training in Statistical Methods
Quality Assurance Programs
5410 Wilshire Blvd. Los Angeles 36, Calif.
WEbster 8-0121

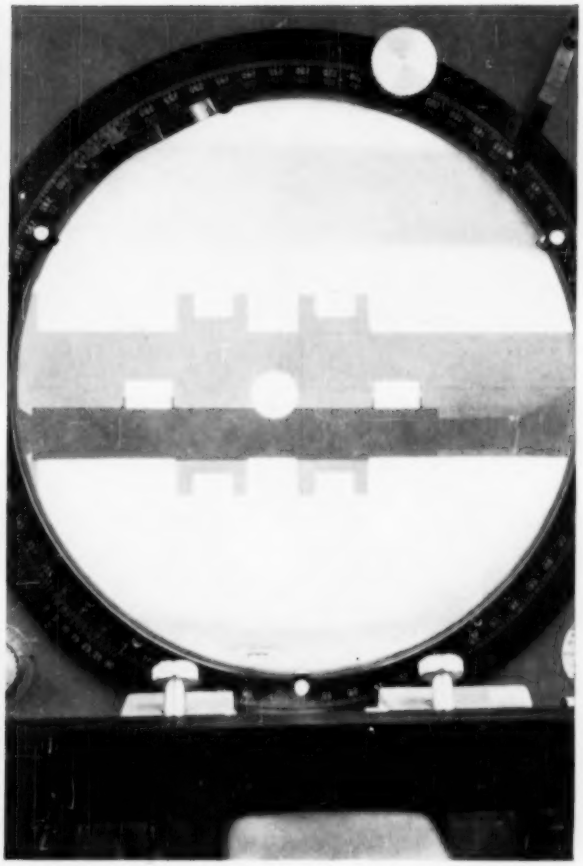
4232 BROADWAY, INDIANAPOLIS, IND. AT. 3-6309
SUTHERLAND-JACOBSON & ASSOCIATES
Consultants in Quality Control
INSPECTION PROCEDURES, PROCESS CONTROLS, STATISTICS FOR RESEARCH AND DEVELOPMENT
M. L. SUTHERLAND, Ph.D., FELLOW ASQC
M. J. JACOBSON, FELLOW ASQC



1. Piston lands on hydraulic control valves are trimmed on a surface grinder fitted with motorized centers.



2. After trimming, piston and sleeve are mounted on worktable of Kodak Contour Projector for simultaneous projection by two light sources to gage amount of stock removal.



3. Overlap of piston and sleeve images is indicated by black area; overlap can be measured quickly by traverse of one part and observation of dial indicator.

How to do a 7½-hour gaging job in half an hour

How would you solve a gaging problem like this one?

In developing hydraulic control valves, engineers at a major firm producing aircraft components worked out a neat method of trimming piston lands in relation to ports in their mating sleeves.

But meeting the required .0002″ overlap between piston lands and sleeve ports meant using several different gages to determine the amount of stock which had to be trimmed. Result: *7½ hours to trim each valve.*

To solve the problem, quality control engineers now use a Kodak Contour Projector with two light sources and two filters, one red and one green. This system projects a superimposed image of the piston on the sleeve. Where an overlap occurs, the red and green images combine into a black image. The width of this black overlap gives the amount of trim required. Result: *just ½ hour needed—7 hours saved on each valve!*

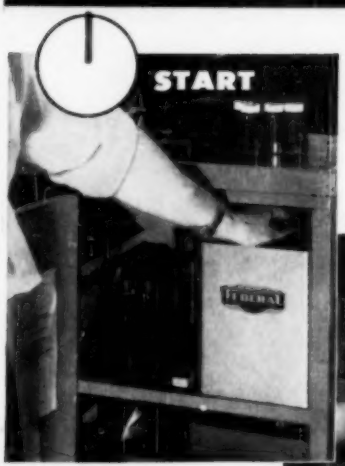
Maybe you've come up against a gaging problem that's eating up time and money in large quantities. To learn how you can solve it by optical gaging, send for the booklet "Kodak Contour Projectors." Write to:

Apparatus and Optical Division
EASTMAN KODAK COMPANY, Rochester 4, N. Y.

the KODAK CONTOUR PROJECTOR

Kodak
TRADE MARK

NEW EASE IN ELECTRONIC GAGING



FROM SHELF THROUGH SET-UP IN 96* SECONDS

*By Actual Test

So much in one small package. The Electro-Probe gage head, Meter-Amplifier, plus accessories, all in one compact, lightweight carrying case. You can use it *anywhere*. The Electro-Probe is completely independent of AC power. Gage head and cord are unaffected by oil or water in any amount.

Only one connection to make, because the Electro-Probe's *transistorized* Meter-Amplifier is powered by a self-contained, long-life mercury cell battery. There's no *warm-up*, no drift, no waiting. Click — it's ON and ready to operate. Turn it off and on . . . at will . . . with no loss of accuracy.

No need to position the gage head critically. Wide range, electrical zero adjustment brings you quickly to exact setting. Master it anywhere within its range. Electro-Probe gaging pressure is *less than 2.5 grams* . . . so light there's no danger of post or arm deflection using ordinary test set or height gage-type fixtures.

In less than two minutes the Electro-Probe is mastered and ready to provide precision gaging — in an ordinary surface plate application. Knob on gage head reverses gaging action. Switch to either of two magnifications (±.002" range with .0001" grads and ±.001" range with .00005" grads). Other magnifications available also.

with the NEW

FEDERAL

electro-probe

ELECTRONIC TEST INDICATOR

ALL THE ADVANTAGES of electronic precision . . . and with a price tag only half that of similar fine instruments. The Electro-Probe . . . because it's so portable . . . so easily and quickly set up . . . so easy to use . . . removes many of the restrictions normally associated with test instrument use. Write for brochure explaining all facts about the Electro-Probe and ask to have it demonstrated at your plant.

FEDERAL PRODUCTS CORP. 8157 Eddy Street, Providence 1, R. I.

Ask **FEDERAL** *First*

FOR RECOMMENDATIONS IN MODERN GAGES . . .

Dial Indicating, Air, Electric, or Electronic — for Inspecting, Measuring, Sorting, or Automation Gaging